The Dock and Harbour Authority

No. 224. Vol. XIX. Edited by BRYSSON CUNNINGHAM, D.Sc., B.E., F.R.S.E., M.Inst.C.E. JUNE, 1939

Editorial Comments

A Notable Inland Port.

Ports of considerable commercial importance, though generally to be found near the sea, are by no means confined to the seaboard and its immediate vicinity. So long as there is navigable approach to an inland situation, a number of reasons offer themselves to cause it to be preferred for the development of commerce and internal transport. Many ports with considerable traffic are, in fact, located at the head of the navigation of rivers and coastal inlets, and some are to be found at remarkable distances inland. Rouen, for instance, is 78 miles from the sea, and Paris, which ranks among the chief ports of France, with a great volume of internal traffic, is no less than 233 miles from the mouth of the Seine.

Among the exemplars of this class of port, Lyons, the third city of France, which forms the subject of our leading article and illustrated supplement this month, takes a prominent place. It stands at the confluence of the rivers Rhône and Saone some 220 miles from the outlet of the former into the Mediterranean and 315 miles to the South of Paris. The long narrow tongue between the two rivers at their junction—a peninsula over three miles in length and from 650 to 1,000 yards wide—has become a district of pronounced commercial and industrial activity. The convenient position of the City has, naturally, made it a great emporium of trade for central and southern Europe, and its staple silk manufacture is known the world over. In addition, large quantities of cotton are imported from America and Egypt, and considerable business is done in cloth and linen, besides foodstuffs, wine, chemical materials, dyeing and machinery.

As will be seen from the article in this issue, there has lately been executed a scheme of outstanding importance for the development of the town's water-borne commerce. A set of three large docks has been constructed with an entrance channel, the design of which has called for careful consideration and experimental investigation, on account of the difficulty presented by the problem of detritus carried down by the Rhône. The account of the tests made at the laboratory at Grenoble with a model of the river covering a length of over three miles will be read with much interest, and should afford useful information for research in similar cases.

The new dock system, which bears the name of the distinguished Frenchman, M. Herriot, for nearly a quarter of a century Mayor of Lyons, and at one time (1924-5) Prime Minister of France, will undoubtedly serve to enhance the commercial prestige of the great city of which it is a notable appanage.

Floating Signals.

Important as they are to mariners in defining a navigable channel and insuring the safety of craft in dangerous and shallow waters, the use of buoys and floating beacons is attended by serious risks to their reliability and efficiency. It was recently pointed out by the Chairman of the Marine Committee of the Mersey Docks and Harbour Board that several cases have occurred of very considerable damage to buoys and beacons in the channels by unknown persons, who, desiring to avoid inconvenient or unpleasant consequences to themselves and utterly indifferent to the interests of others, neglected to report these accidents, though these, if ignored, might entail unfortunate, and even catastrophic, results to navigation. The matter is so serious that a special appeal was made to shipping companies and others to assist in tracing those responsible for the damage in question. It might conceivably be the lot of such irresponsible individuals to bring upon themselves the well-deserved fate of Sir Ralph the Rover, who cut the bell of the Inchcape Rock and subsequently perished there by reason of the lack of its customary warning.

Another danger, happily of less usual occurrence, to which lighted signals are exposed, is that of explosion, two regrettable cases at Calcutta being reported in this issue. As the cause of these particular instances is still obscure and the matter under investigation, it would be premature to discuss the circumstances at the moment, but they serve to give rise to reflection on the responsibilities attaching to the use of highly inflammable and explosive substances for buoy illumination, though, at the same time, the system may present very great advantages and have a long record of safety and security.

Dundee Graving Dock Accommodation.

It is not only in South Wales, the subject of our comment in the last issue, that concern is being expressed at the paucity of dry-docking facilities for British vessels to meet casualties following an outbreak of hostilities. The matter was broached at a recent meeting of Dundee Harbour Trustees, when the need for a new and larger graving dock to supplement the local port resources was voiced by several members. It was urged by Mr. D. M. Christie that the present facilities were inadequate and, according to a report of the meeting in the Dundee Courier, he went so far as to allege that the existing graving docks were dangerous to work in—" a burst foundation, with leaks here, there and everywhere." Mr. Henry Main, speaking from the shipbuilders' point of view, emphasised the helplessness of the port in the event of a war, without a dry dock capable of accommodating the visiting vessels.

After some discussion, it was decided, on the suggestion of the Chairman, that the Port Facilities and Grants Sub-Committee, with the addition of a Caledon representative, should be authorised to meet the Lord Provost and members of the Town Council and the Chamber of Commerce, in order to lay the facts before them with a view to taking concerted action.

There can be little doubt that the Dundee Harbour Trustees are adopting a prudent course in making provision for a contingency which is by no means remote, and if the state of the existing facilities is as alleged, the need for attention to the matter is only too evident. Other port authorities, who may be similarly situated as regards inadequacy or disrepair of accommodation, would be well advised to give equal consideration to their responsibilities in a national emergency.

The Port of Hamburg Anniversary.

Records extending back for over seven hundred years constitute for a port a respectable degree of antiquity, and Hamburg is to be congratulated on the celebration of its 750th anniversary. Of course, mere antiquity is no reliable criterion of a port's prestige, as witness the decay which has befallen the ports of Tyre and Sidon and many others renowned in past ages. But Hamburg has succeeded, where others have failed, in maintaining a consistent progress, and to-day, as it has been for some time past, it is Germany's chief port. It has had its vicissitudes, of course. During the Great War, its trade sank to negligible proportions, but it has made a striking recovery, and the turnover has since reached a figure of nearly 26 million tons.

Editorial Comments—continued

It was during the eighteenth century that the port made its most significant progress. Following the close of the Napoleonic Wars, despite temporary setbacks, it became by degrees the chief importing centre of the Continent of Europe. Then the advent of steam power led to a great extension of overseas traffic, which ultimately brought Hamburg into the front rank as a port for transatlantic shipping.

The extensive dock system dates from the middle of last century. Though termed "docks," the water areas in question are essentially basins, having free access to the river, unimpeded by lock entrances, though gates are provided to exclude the silt which it brought down the Elbe.

The inauguration of the Kaiser Wilhelm Canal enabled Hamburg to develop its Baltic Sea connections and to take a substantial share in northern coastwise traffic. But perhaps it is mainly as a result of its connection with a great network of inland waterways that the port has been able to attain so dominating a position in German trade. Recent enterprise has extended its hinterland enormously and with the opening of the Mittel-land Canal and other inland waterways, the trade of Hamburg is attracted from the furthest limits of Central Europe.

An interesting feature of its history is that, as recently as 1935, the previously existing State Quay Administration—dating from 1866—was dissolved and the activities of the renowned Free Port transferred to a private organisation: the Hamburger Freihafen-Lagerhaus-Gesellschaft, which now controls both the quay services and the warehousing business. As far as can be judged from recent returns, the change seems to have had a beneficial effect.

Fishery Harbour Grants.

The 28th Annual Report of the Development Commissioners for the year ended 31st March, 1938, contains an interesting section on Fishery Harbours, dealing with a number of cases in which financial grants have been made to supplement local resources or to provide in their entirety sums of money required for necessary improvements or maintenance. The harbours in question are two in England (Polperro and Whitby) and seven in Scotland (Anstruther, Campbeltown, Lybster, Macduff, Nairn, Portnockie and Wick). In all, an amount of £66,661 has been advanced, or recommended, for the reconditioning and improvement of fishing harbours.

The policy of making such grants, as a national contribution towards the support of the British fishing industry, needs no justification in view not only of the fact that it is of direct benefit to the brave and hardy race of fishermen who toil along the coast and far overseas to win a scanty livelihood—themselves the recruiting field and mainstay of the British Navy—but because of the indirect advantages to the various dependent activities associated with the marketing and disposal of the catches.

Of the nature of the work carried out by means of these Treasury grants, the more important are those of dredging, as at Nairn, Lybster and Wick, and breakwater and sea wall repair as at Polperro, Portnockie and Macduff.

It is indicative of the poverty of many of the places under consideration that at Lybster, where necessary repairs were estimated by the Fishery Board's Consulting Engineer to cost £1,118, the number of fishermen at the harbour was 62, the average annual income £47 and the expenditure £38. At Whitby, a larger harbour administered by the Whitby Urban District Council, successive annual deficits of £3,429, £3,800 and £4,074 have recently been experienced, and these had to be met out of the local rates. In the application for assistance it was urged that "there was much local interest in the fishing industry, that a good type of seaman was fishing from Whitby and there was a keen desire among the younger generation to obtain regular berths in local boats."

The creation and fostering of a sea-going disposition on the part of inhabitants in the British Isles is a very serviceable function of the Development Commission and it deserves the fullest support. In time of war and national emergency, the country turns to its sailors and fishermen for aid and they have never failed to respond.

South African Harbour Problems.

There seems to be a considerable degree of controversy prevailing in South African shipping and port circles over the respective schemes of development which are in process of execution at the harbours of the two leading ports of the Union. At Capetown, the discussion centres round the construction of a large graving dock which formed part of the original plan of port extension, but which for some reason, probably financial, but not altogether clear, seems now to be in abeyance, despite the fact that preliminary surveys and borings on the site have been made. The construction of the new harbour breakwater, on the other hand, is proceeding apace and shortly Capetown will possess a capacious basin for the reception of shipping, for which it is to be hoped a satisfactory entrance will be provided. This too, is a problem with partizans in favour of divergent views.

At Durban, where rapid progress is being made on an improvement scheme, estimated in its entirety to cost 3½ millions sterling, which includes new deep water berths at Cato Creek extending along a 6,280-ft. frontage, misgivings are being expressed as to the efficiency of the present harbour entrance, which is liable to closure under stress of weather. It is reported that on, at least, three occasions during the past winter season, the bar entrance has been closed to both incoming and outgoing shipping for periods of 12 hours or more. As uninterrupted accessibility is an essential requirement of modern port operation in order to obviate dislocation of shipping schedules and prevent financial loss, the inability of Durban to come up to such a standard is felt to be a serious reflection on its prestige. Whatever be the cause of the trouble, there is a general concurrence of opinion, voiced by the Chairman of the Harbour Advisory Board, that the matter should be the subject of prompt investigation.

The Two Dromios.

The complications arising out of identity of nomenclature in the case of certain ports, especially when they are in fairly close proximity, is illustrated by an incident which occurred recently at Dundee. There are two ports on the East Coast of Scotland which are named Newburgh, both at no great distance from the mouth of the Tay. Arriving at that river during the night time, a Dutch motor ship signalled for a pilot to take her up the Firth to Newburgh (Fifeshire). Unfortunately, this was a mistake, the true destination of the vessel being Newburgh in Aberdeenshire, about 80 miles further north. The reverse journey had accordingly to be made, causing delay, in addition to the expense incurred for lighting and buoyage dues in the Tay. As both ports are accessible only to vessels of light draught and are used by the same class of tonnage, the mistake was natural enough, though its consequences were inconvenient.

Such cases of duplication are not uncommon. Perhaps the best known is that of Boston (Lincs) and Boston (Massachusetts), but, in this instance, confusion is hardly likely to arise on account of the enormous distance between them. There are about a dozen Newports—four of them in the British Isles and two of them less than 150 miles apart. There are two Port Arthurs, two Port Talbots, two Port Victorias, and so on. Perhaps among so many ports in the world, the wonder is that relatively so few of their names are in duplicate.

Londonderry Harbour Dredging.

It is reported that substantial progress is being made with the Londonderry Harbour Commissioners programme for improving the port approach through Lough Foyle. From Londonderry to the sea the channel is being deepened to 20-ft. at low water so as to enable vessels of 24 or 25-ft. draught to enter the port during high water of neap tides. The work has been carried on energetically, but owing to severe climatic conditions during the latter part of last year there was considerable retardation. Despite the drawback, however, since operations were commenced in April, 1938, some seven miles of channel below Culmore have been deepened and nearly a million cubic yards of soil removed to sea, thus far completing the operations in Lough Foyle.

At the present time the dredging plant is working in Rosses Bay, removing the point of the bank near Crook Light. This work involves the removal of about 400,000 cubic yards of material. When the scheme is completed the navigation of large vessels through Rosses Bay will be considerably facilitated by the longer and easier curve. Dredging of the existing channel in Rosses Bay is being proceeded with at the same time.

When the whole of the dredging work is completed, which it is expected will be in a few months' time, there will be a depth of 27 to 28-ft. at high water ordinary spring tides, and from 25 to 26-ft. at high water at neap tides throughout the entire channel to the sea. The Government of Northern Ireland have contributed a grant of £25,000, or one-half of the cost of the scheme. The contractors for the work are the Tilbury Contracting and Dredging Company, Ltd., London, and the work is being carried out under the supervision of Mr. John S. Watt, Derry Harbour Engineer.

The Institute of Transport Congress.

It is fitting that this year's Congress of the Institute of Transport should be held at the Port of Southampton, with which the present President has been so closely and honourably associated. Our readers will recall that Colonel Szlumper spent some years as Docks and Marine Manager at the great passenger port of the United Kingdom, and did much to foster its overseas activities. It is a matter of interest and pleasure to announce that his successor in the position, Mr. R. P. Biddle, is to read a Paper on the Port of Southampton. The Congress will be in session from June 14th to June 17th, and the proceedings and visits associated therewith promise to be of much service in the cause of the science of transport.

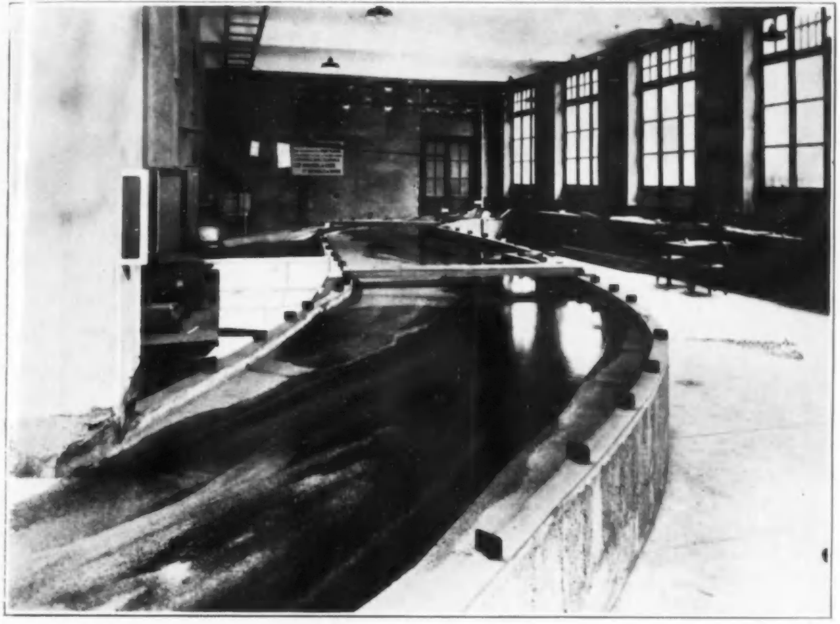
River Port on the Rhone

*The Edouard Herriot Docks at Lyons**

By Messieurs DELATTRE and COUTEAUD, Chief Engineers, "Ponts et Chaussées," and respectively Technical Director and Chief Officer of Navigation in the National Company of the Rhone.

THE "Compagnie Nationale du Rhône" holds a general concession of the river, from the Swiss Frontier to the Mediterranean, covering the three interests of navigation, irrigation and hydraulic power. The general conditions of the concession provide for the construction, as one of the improvements most urgently required, of a large river port at Lyons, where the Saone joins the Rhone.

The Rambaud port or quay on the Saone, constructed by the Lyons Chamber of Commerce and opened in 1926, has developed very rapidly, but its area is of very limited extent and already used to its full capacity.



General View of the Model (fig. 9)

The City of Lyons, anticipating this success, had for some time contemplated the construction of a second port and, by skilful and persistent policy, had reserved suitable lands for the purpose, adjoining the Rhone and on the outskirts of the town. In 1934, the Chamber of Commerce, acting in conjunction with the Rhone Navigation Service drew up a preliminary project for an industrial port, on the model of the Rhine ports, and opened negotiations for its realisation. Thanks to this collaboration and to the action of the National Company of the Rhone under the energetic leading of its President, Senator Leon Perrier and its General Manager, M. Aubert, Chief Engineer of the Ponts et Chaussées, the Company was able to commence the works early in 1935, only a few months after its own constitution.

The progress made was such that, on the 31st March, 1938, the Company's own tug was berthed in the Oil Dock, alongside which the first tanks were already erected and the importation of oil and spirit began soon afterwards. It may be of interest to describe this new port, which is named after President Herriot.

First will be given a general description, secondly an account of experiments made with scale models to determine the best form of entrance. A third section will describe the execution of the works and lastly will follow some particulars regarding the operation of the port.

I. GENERAL ARRANGEMENT

(1). Situation

The port is situated on the left bank of the Rhone, on the Southern border of the Town of Lyons, in the heart of its industrial suburbs, and is connected with the principal goods station, the Guillotière Station. (See fig. 1 on Supplement). It covers 150 hectares (370 acres) of land, which had previously been liable to floods.

The channel of communication with the river joins it at 3½ kilometres (2 miles) below the confluence of the Rhone and Saone.

The future encircling canal, the commencement of the navigable waterway of the Upper Rhone, which is to connect Lyons with Geneva and which is included in the Company's concession, will open into these docks.

(2). Docks and Quays

The entrance channel, which is 700 metres long and 90 metres wide, leads into a basin with a turning circle of 200 metres diameter, commanding the entrances to the several docks (fig. 2 on Supplement). These are three in number, being:—

The Oil Dock: 535 metres long and 70 metres wide (fig. 4).

Dock No. 1: 80 metres wide, which is to have a length of 625 metres eventually, but only 400 metres in the present programme;

Dock No. 2: 1,000 metres long, of which the construction is to be deferred until it is justified by the growth of trade.

The docks have free connection with the Rhone by way of an approach channel and an embayment intended to prevent the silting up of the entrance.

The water level varies between the extreme limits of 156 metres—dry weather flow—and 162.9 metres—highest recorded flood. The bottom level of the docks is at 153.5 metres, giving a minimum depth at any time of 2½ metres. This minimum gives flotation for entry into the docks not only of the specially low-draft Rhone vessels but also of Saone craft and of the canal barges which ply in that river.

The width of the approach channel is sufficient to allow boats to lie up there without impeding circulation. The total length of quayage in the docks and the channel amounts to 6,300 metres, or about 4½ miles.

The general quay level is fixed at 163.5 metres, giving a height of 60 cm. (2-ft.) above highest recorded flood.

The width of quay and of reclaimed land behind it varies between 150 and 200 metres, except on the South side of the channel and of the Oil Dock, where this width does not exceed 90 metres. The area of land is about 112 hectares (280 acres), retained at waters-edge either by vertical quay walls or by revetment.

Fig. 3 on Supplement shows the cross-section of these revetted banks. The lower part of the slope is simply cut in the natural ground, trimmed to an angle of 2:1 and left bare. At the level of 157 is driven a curtain of sheet piling of rust-resisting steel, which supports the lower concrete revetment, carried up to the 160 metre level, where there is formed a concrete berm 75 cm. wide, with a second curtain of steel sheeting, supporting the upper revetment which rises to the cope level.

In line with the toe of the slope is a row of dolphins, each consisting of three timber piles about 14-in. square.

The first stage of the works now in progress comprises the entrance channel, the oil dock, part of No. 1 Dock and reclamation to the extent of 80 hectares or 200 acres. In this first stage, the length of quays to be constructed is limited to 3.8 kilometres, or 2½ miles.

(3). Access to Port

The general arrangement of the port provides for every part of the area to be accessible by water, rail and road.

1. **Access by Water.**—The approach channel opens into a concave bend of the river (fig. 1 on Supplement), wherein depths suitable for navigation are maintained by natural forces. It is important to note that convoys of great length can manœuvre in the neighbourhood of the port, because it is well known that the manœuvring and the stopping of convoys are often difficult on the Rhone.

To enable craft to lie up, a line of mooring posts has been established along the left bank of the river, downstream of the port entrance. This is composed of twelve dolphins, of substantial construction, each of them being formed of six timber piles, 40 cm. square, 14 metres long, with a cap of reinforced concrete (fig. 6).

The National Company of the Rhone has had a tug built for service in the port and at the riverside moorings. It can also tow Saone boats and canal boats between the port and the Mulatière sluices at the confluence of the Saone (fig. 7). This tug is specially fitted to tow the canal boats two abreast in the swift currents of this short reach of the river.

* From the "Annales des Ponts et Chaussées," October, 1938; translated and reproduced by permission.

River Port on the Rhone—continued

2. **Railway Access.**—An extensive group of sorting sidings is to be laid down to the East of the port, comprising twelve tracks of a total length of 7.7 kilometres (4¾ miles); but in the first stage of development there are only three tracks each 640 metres long, which can easily accommodate full trains of heavy tonnage. A system of railways, connected with the sorting sidings, encircles the dock estate and serves the whole area. The sorting grid is connected with the Lyons-Guillotière station of the National Railway Company by a link-line, the construction of which has necessitated that of numerous bridges, retaining walls, etc., since it runs through a highly-developed industrial area and no level crossing has been permitted.

3. **Road Access.**—The port area is bounded, all round its outer border, by public avenues 30 metres (100-ft.) wide, laid down by the City of Lyons and by the Company in collaboration. These avenues are directly connected with the main urban arterial roads, which lead to the heart of the city, with the boulevard encircling it and with the other main roads radiating from this. They will also be connected with the proposed future system of motor-ways of the Lyons district, of which the Southern artery will cross over the dock entrance channel by a bridge proposed to be constructed at this point (fig. 2 on Supplement).

Within the port boundaries, a network of private roads, 14 metres wide, serves the whole area. This system will eventually include 8 kilometres of roads; but in the first stage only 4.3 kilometres (2¾ miles) are to be laid.

II. DETERMINING THE SHAPE OF THE PORT ENTRANCE. EXPERIMENTS WITH SCALE MODELS

The Rhone carries down much gravel, sand and silt. The very difficult question of the best form to give to the port entrance, in order to avoid its losing depth by deposit and the formation of shoal banks, which might endanger the freedom of access, has been examined by the method of experiment on small-scale models.

These experiments were undertaken at the laboratory of the School of Hydraulic Engineering at Grenoble, with the collaboration of the staff of the laboratory, but under the effective direction of the Company's engineers. A brief description will now be given of what was done.

(1) Determination of Scale and Selection of Material Experimental Arrangements

It was necessary to reproduce the river for a length extending to 5 kilometres downstream from the confluence of the Saone. It was thought best to make it in one of the rooms at the laboratory (fig. 9) and not in the open air, and this restricted the horizontal scale to 1/150. With this scale, it is necessary to have a larger vertical scale, in order to obtain adequate depth and velocity of flow in the model.

The choice of vertical scale, of hydraulic gradient and of aggregate must be made simultaneously, in order to secure in the model the desired friability of the bottom and to effect the same formation of the bed by the flow of water as occurs in nature.

It is known, moreover, that the size of grains in the aggregate cannot be deduced by geometrical proportion from that of the material in the river bed: what is desired is to make it so that similar discharges produce similar movements in the model to those in nature; the solids discharged at extreme low water being nil; at mean level, sand and fine gravel; at high flood, general erosion including pebbles and tending to undermine the banks.

The determination of scale and selection of suitable aggregate present a serious difficulty in this sort of experiment. After numerous attempts, which it would be tedious to describe here, the choice was made of an aggregate possessing the following characteristics:—

(1) white grains, of diameter between 2 and 5 millimetres, forming about 20% of the mixture;
(2) black grains, of diameter between 1½ and 2 millimetres, forming 60%;
(3) fine powder, made by crushing a mixture of the two kinds (1) and (2), forming the other 20%.

There are no grains between ½ and 1½ millimetres.

In the model, at the scales adopted, the fine powder behaves like the sand in the river bed, the white grains like the gravel and the black grains like the larger pebbles. The differences of colour assist in observation. It is noted, moreover, that this aggregate does not produce an undulating bed, which it is important to avoid.

The scales adopted are as follows:—

Horizontal	1:150
Vertical	1:50
Direct distortion	3:1

The gradient in nature is 4:10,000, and in the model is 0.012. The scale of discharge is 1:50,000

An ingenious arrangement devised by the laboratory staff enabled the aggregate, including the powder, to be recovered in a settling tank placed below the model and in the discharge flume leading from it. The aggregate was sucked up by a gravel pump and delivered to the upstream end of the model. This ensured a continuous and automatic supply of solids. The measurement of the hydraulic gradient was effected by reading from gauge boards similar to many already in existence along the Rhone.

Observation of surface currents was assisted by sprinkling aluminium powder on the surface of the water, as this shows up well in a photograph. Observation of currents at a lower depth was facilitated by introducing through a pipe a coloured liquid of the same density as the water but not mixing with it.

(2) First Series of Trials, for Calibration of the Model

The solid surfaces of the model were moulded in masonry and concrete of suitable texture; the quays, revetments, jetties and spurs of the river bank were all reproduced. The concrete representing the river bottom was never exposed; it was covered by a layer, about 8-in. deep, of powdered pumice, to simulate the erodable bed. This layer was in the first place simply smoothed over and adjusted to levels corresponding to the average levels of the real river bed, without taking account of banks or of hard and soft bottoms.

These trials for calibration, while not independent of those made for choice of scale and of aggregate, had for their object the confirmation of the assumption that, after many repetitions of the cycle of flood and low water, the model of the bed of the Rhône would become a true reproduction of the original by the effect only of the flow of water. After many attempts, these were successful in inducing discharges similar to those in nature and a satisfactory contour of the river bed, except between 2 and 2.7 kilometres. In this section, the model indicated erosion to a great depth along the right bank and the formation of a very narrow and very deep channel, of a V-shaped section, whereas in the river itself there is a navigable channel of greater width, less depth and regular form. In the model, the channel had the character found in an unregulated river. The question therefore arose whether in fact some unknown works of regulation had at some time been effected in this section.

A survey and soundings on the site revealed artificial sills of considerable age, and a search among records brought to light corresponding projects of regulation, which must in fact have been carried out. These sills were then reproduced in the model, forming them in concrete; but the results of this modification were not at all satisfactory. The concrete sills induced eddies and an exaggerated erosion between them (see fig. 10). It was therefore decided to replace the concrete by sills or bars composed of small pieces of cast iron, which would more suitably represent the rubble stone sills in the river. This change was successful in achieving the desired result, consolidation took place between the sills, the channel widened and a faithful reproduction of this portion of the bed was obtained (see fig. 11).

In the end, the model as a whole fairly represents the general form of the real bed; the depths obtained are everywhere closely approximate to those in nature, with divergences not exceeding 10%; a truly remarkable result.

In the course of this process, it established in an empirical way a cycle of high and low water flows which induced a correct modelling of the bed. This demonstrated at the same time the preponderant effect of mean flow in the formation of the bottom.

These results showed that the desired calibration was achieved, that the model constituted a true representation of natural conditions and that the way was now open to undertake a study of the proposed works at the entrance to the port.

(3) Trials Properly Relating to the Proposed Port Entrance Works

The original proposal for the port entrance is shown in fig. 4 on Supplement; this was reproduced in the model. Trials were at once made, by flow and ebb of water in and out of the port, and showed that no gravel was carried into the entrance channel. On the other hand, a large bank forms in the river at the mouth of the port entrance and almost completely blocks it. The banks thus formed are of such a height as to be exposed at low water. The adoption of the form proposed in the initial project would therefore induce the formation of deposits necessitating continual maintenance dredging.

In the course of trials that followed, it was found that the river current did not hug the left bank closely enough, in the neighbourhood of the port, and that it did not have the scouring effect that was expected of this current running against a concave bank. When the training wall is lengthened and carried further out it is found that, after passing it, the main stream impinges below the port entrance, against the projection of the bank, the current then dividing into two branches, one of which flows downstream carrying material with it, while the other flows up towards the port entrance, forms eddies and induces deposits which obstruct the channel mouth. (See fig. 12). It therefore appears necessary to modify the line of the left bank below the entrance, by reducing its projection and giving it instead a contour suiting the stream line.

River Port on the Rhone—*continued*

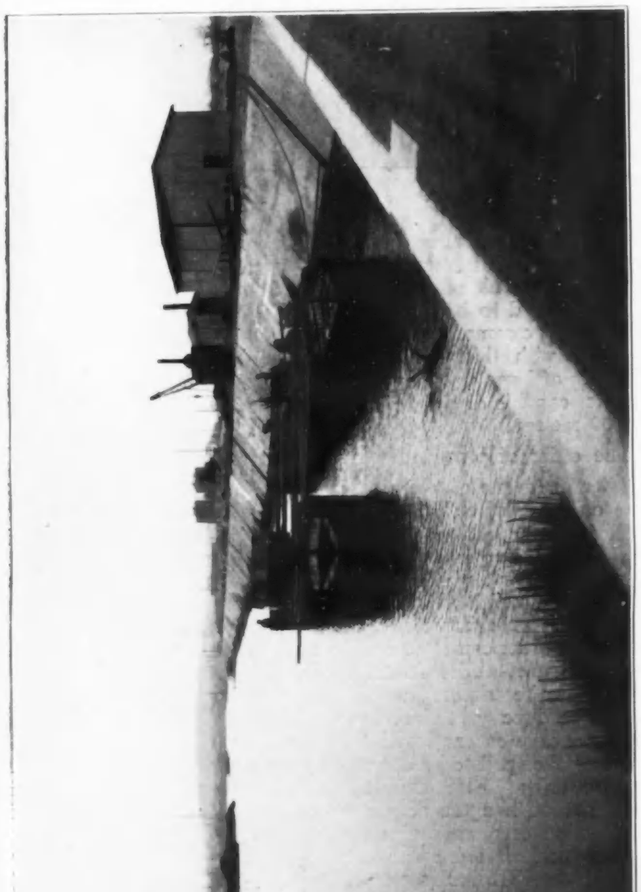


Fig. 5. Oil Dock, in January, 1938

Fig. 6. Line of Dolphins, in middle distance, and Diesel-driven Suction Dredger at junction of dock entrance with river

Fig. 7. The Company's Tug

Fig. 8. Cutter of the Suction Dredger

River Port on the Rhone—continued

This modification effects a certain improvement, the volume of the deposits is reduced, but they are not eliminated altogether and troublesome banks continue to form systematically at the port entrance.

During the experiments it was noticed that deposits did not form so long as the bottom currents were sufficiently guided by the left bank and so long as they maintained a sufficient velocity. This is what happened along the training bank and for about 30 metres below it; hence arose the idea of extending this by a submerged bank to guide the under-currents.

Various forms of bank were tried out, ending in that shown in fig. 4 on Supplement. The bank is brought up to a horizontal crest, at an elevation of about 1.8 metres above low-water level. It is 20 metres in length, and in plan has a fairly sharp curvature outwards. It leaves an open entrance to the channel, 35 metres wide, and sufficient for navigation.

This bank has a double effect. When the discharge of the river is sufficient to carry down an appreciable quantity of material, while insufficient to submerge the bank, the current of the Rhone hugs it and hollows out a channel at the foot of it; the greater part of the material transported is guided by the bank towards the open river and is carried away by the stream. Yet a small proportion enters the channel and occasions deposit at the mouth of it, though to a less extent than before.

When the water rises, it passes over the top of the bank, creating currents across the channel which scour the entrance and carry away more or less completely the deposits previously made. During floods, certain banks tend to form downstream of the training wall, along the submerged dyke. They seem to give no trouble and tend in turn to disappear during the ensuing period of mean flow.

Fig. 10. Concrete Sills in model of River bed

Fig. 11. Disconnected Sills made of pieces of cast iron

(4). Conclusion

In recapitulation, the experiments made have led to the following improvements:—

1. The setting forward, by about 15 metres into the river, of the concave portion of the left bank, so that it may be more closely hugged by the current. Also, on the right bank upstream, spurs are to be formed to assist in this respect. These modifications tend to give to the banks in this region a form more nearly resembling the theoretical form for river regulation according to Girardon.

2. The setting back of the left bank, immediately downstream of the entrance channel, to form a stream-lined contour and prevent the creation of eddies and back-wash towards the channel and the docks.

3. Extension of the training wall by a submerged dyke, which guides the under currents and induces flow diversions that ensure a certain amount of automatic scouring away of deposits at the port entrance.

No doubt there will be continued formation of deposits at the meeting place of the still water in the port and the flowing water of the river; it is too much to hope that the automatic scouring just mentioned should be sufficient by itself; the use of dredgers will probably be necessary from time to time to maintain depth in the entrance. Yet the improvement effected in consequence of these methodical experiments is considerable, and it may be asked whether the solution thus found may not be of so general a character as to afford guidance in all cases of investigation into the best form to be given to port entrances that are liable to siltation.

III. EXECUTION OF WORKS

(1). Major Construction

The docks are excavated in a soil which, for a practically unlimited depth, consists of sand and gravel, and is covered by a generally thin layer of vegetable earth or of mud. Consequently, the material excavated is of good quality and very suitable for reclamation. It was, in fact, necessary to raise the ground from its natural level of 159 metres to 163 metres, in order to safeguard the port area against flooding. The project is so designed that cutting and filling are equal.

This soil of sandy gravel forms an excellent foundation, and the port works have in all cases been of the simplest form. But there is water to contend with, for any excavation into these very porous and water-bearing strata fills with water immediately. The existence of local wells of high capacity for the supply of various factories showed from the first that it would be futile to think of digging in the dry. So the excavation of the docks had to be accomplished by dredging. The work in the first stage comprised 1,150,000 cubic metres of earth removal. To deal with this, the undertaking employed two suction dredgers of large output, one with Diesel engines and the other electric, capable of delivering the dredged material to a distance of 500 metres.

The order of procedure was as follows:—

After clearance of the site, the first thing to be done was to take off the surface soil with the help of several shovels. The spoil from the shovels had to be removed by wagons, and it was employed to make up the filling required for the support of roadways and of the group of sidings in the Northern area of the port, which was too far away from the dock excavation for the discharge from the suction dredgers to reach it.

Next in order came the cutting of the outline of the excavation with a bucket-ladder land-dredger, this machine enabling the margins to be trimmed to any desired slope, a result which cannot be directly attained by a suction dredger.

The excavator employed was fitted with a belt conveyor, enabling the spoil to be deposited over a width of 23 metres and thus to bring the reclamation to the edge of the excavation. This method had the advantage of facilitating the operation of the suction dredgers by preventing the silt-laden water from running back into the excavation. The land dredger generally worked three 8-hour shifts per day, and reached an output of 2,000 cubic metres per day.

Behind the excavator follows a shovel with crane attachment for driving the steel sheeting of the revetments. The concreting of the revetments is done immediately after, the concrete being made with aggregate arising from the dredging.

River Port on the Rhone—continued

Fig. 12. Eddies at entrance to Port

Alongside this formation of the revetments, the bulk of the excavation is carried out by means of the two suction dredgers. These are both of similar type, except that the electrically-driven machine, being less powerful, smaller and cheaper, has likewise a lower output than that which is Diesel-driven. It may be of interest to give a brief description of the latter dredger.

The Diesel-driven suction dredger is mounted on a steel-plated pontoon, whose width is reduced to 5 metres to allow it to navigate the canals: two detachable floats are connected with it when at its working station, in order to increase its stability. It is fitted forward with mooring winches and aft with a pair of spuds to take a bearing on the bottom. It has two Diesel engines, one of 650 h.p., driving the suction pump direct, the other of 400 h.p. driving a dynamo which feeds all the auxiliary services.

The principal adjunct is the rotary cutter, which is fixed at the end of the suction tube: fig. 8. This cutter consists of a cast steel cap with detachable blades of hardened steel. The driving shaft of the cutter is driven by a 40-h.p. motor placed at deck level. The lower part of the cutter is liable to be choked by the material in which it is working, and is therefore fitted with a water jet.

The dredging pump is of the centrifugal screw type, in manganese cast steel, the stator being a spiral of 1.9 metres (6-ft. 3-in.) diameter, held in place by keys in a malleable cast iron casing.

The rotor, which is also in one piece in manganese steel, has three blades. It is fixed on the driving shaft with a clutch which disengages when an abnormal resistance is encountered.

The gland which ensures watertightness on the motor side is protected against the passage of sand or gravel by an injection of pressure water.

After pumping about 50,000 cubic metres of spoil, the rotor and stator are dismantled (fig. 13), repaired and reconditioned by welding. They require renewal after some 1,300 hours working.

The suction consists of a 40-c.m. (16-in.) tube of cast steel, connected by a short detachable bend to the pump casing. This is easily removed for inspection of the pump. It wears out quickly.

The delivery of spoil is effected by means of a floating pipe line, made up of pipes 6 metres long, carried by floats and connected by knuckle joints. Delivery has been effected to a distance of 500 metres.

The output guaranteed by the makers is 150 cubic metres per hour. The output actually attained has been of that quantity but for a shorter distance. The solids discharged amount to about 10 to 15% of the total fluid discharge.

The suction dredger works night and day, giving an average delivery of the order of 1,100 cubic metres per day, maintained notwithstanding a high proportion of large stones. It was found that pebbles or pieces of rubble of a volume of 6 to 8 decimetres ($\frac{1}{4}$ cu. ft.), and a length of 8-ins. could occasionally be sucked up and discharged without any ill effect.

(2). Auxiliary Works

In addition to the principal works, quite a series of subsidiary works had to be carried out.

Several 70,000-volt electric cables which crossed the port area were diverted. A large pumping station in the middle of the entrance channel had also to be dismantled and rebuilt. The new pumping station is situated between the channel and the River Rhone. It feeds two deliveries, each of 60-c.m. (24-in.) diameter, which cross the channel by a bridge placed near the port entrance and indicated in fig. 2.

The oil dock has been given a special outfall drain, $2\frac{1}{4}$ kilometres (nearly $1\frac{1}{2}$ miles) long, large enough to be accessible for internal inspection, discharging direct into the river. This drain was made of concrete reinforced with steel mesh, moulded in metal forms, which were vibrated. A specially devised arrangement of the metal forms enabled these to be struck and moved forward in 10-metre lengths, a method which proved economical.

Besides the laying of roads and railways, it was necessary to provide for the supply of electrical energy. An underground network, at 400, 3,000 and 10,000 volts, serves all parts of the area. A fresh-water system is installed for supply to ships, administration offices and the buildings of users of the port; it provides also for fire service and for cleansing of the port roadways.

The lighting system is by three-phase current at 400 volts, using filament lamps at 24 volts, having individual transformers. The lighting of roadways is effected by lamps at a height of 9 metres and spacing of 40 metres apart. The lighting of the docks and quays will be effected when necessary by flood-lights mounted on wheeled carriers and drawing current from underground feeders placed alongside the quay coping.

IV. PORT OPERATION AND MANAGEMENT

The Edouard Herriot port comprises three sections: public, industrial and petroleum.

The public part, comparatively limited in area, is at the South-East of No. 1 Dock, where it is intended to construct a straight quay 200 metres long. This will be essentially a transit quay, furnished with sheds for sorting and housing cargo, and with store-rooms leased to the public. The handling of goods will in general be done by the port staff and equipment.

All the rest of the enclosed reclaimed areas, that is to say, nine-tenths of them, constitute the industrial port. These areas are let by the Company to manufacturers and merchants on long leases, which may be for as much as 40 years. The lessees are allowed to develop their holdings to suit their own needs

Fig. 13. Spiral Casing of the Gravel Pump. (Note the hole needing repair)

and to install whatever plant or equipment they may desire: factories, work yards, stores, sidings, handling machinery, etc. This arrangement, although rather a novelty in France, has been found to give good results abroad, notably in river ports on the Rhine.

River Port on the Rhone—continued

Petroleum Port

The petroleum port is a specially allotted part of the industrial port, and comprises the areas adjacent to the oil dock. The foregoing principles of management apply equally to this section of the port.

It is common knowledge that petroleum installations are the subject of official regulations and of increasingly stringent restrictions. The Company has secured general authority for the storage of 46,400 cubic metres of first-class products ("white oils ")* and 1,600 cubic metres of spirit. Tanks may, of course, be provided for second-class products (" black oils ")*. These are included in the total capacity just mentioned, but only for two-thirds of their real capacity. The Company has the right to sublet to other concerns the general authority obtained.

A typical cross-section of a petroleum wharf is shown in the Supplement. It will be seen that the storage is served on one side by water and railway, and on the other side by road. A strip of 5 metres is reserved between the railway and the quay for pipe lines.

These arrangements are very favourable to traffic. Road tank wagons can circulate within the petroleum port and can enter particular depots without being impeded by any level crossing, notwithstanding the numerous branches, each oil concern having its own siding. Similar principles apply throughout the whole of the industrial port.

In conclusion, a few words may be said about the very complete special measures taken in the petroleum port for passive defence and for fire protection.

In conformity with the latest regulations of the National Liquid Fuel Office, the oil tanks are arranged in groups of three—A, B, C—spaced at some distance apart at the three corners of a triangle (see fig. 2 on Supplement) without counting two small areas specially reserved for spirit. The groups comprise storage tanks for " black " and " white " oils, the latter being separated from the former by a minimum distance of 25 metres. The spirit tanks must be placed within the tank enclosures. Outside these and near them, the oil companies erect their filling and discharging plant, pumping stations, office buildings, etc.

The tanks have to comply with stringent safety regulations, and are built within enclosures of a capacity equal to that of the tanks themselves, the enclosure walls being calculated to take the pressure of water filling them to the top.

The fire-protection measures are very complete. Every stockholder must install a small central foam plant, with piping therefrom to each tank. Further, every group of tanks is encircled by a foam pipe that is also connected with the central plant. This pipe is fitted at the four corners of the group with couplings to which can be connected the portable foam-producing plant of the Company. This arrangement enables the pump to be connected at any point and to function without difficulty whatever may be the direction of the wind driving the flames. Of course, the Company does not intervene unless the small individual foam-plant of the stockholder concerned is unable to cope with the fire. In case of need, the City of Lyons' fire brigade can likewise connect their equipment to the ring mains surrounding the tanks. Furthermore, the harbour tug is fitted with special fire-fighting plant. It has a powerful pump delivering 850 cubic metres of water per hour, and a fire-foam generating plant. This tug would prove especially useful in case of fire on board an oil tanker.

In respect of passive defence, the arrangements described are supplemented by shelters for the protection of staff against air raids, a first-aid post, alarm sirens and a system for the instantaneous extinction of lights.

It is expected that the Edouard Herriot port, being conceived on a generous scale, will contribute to the development of navigation on the Rhone and to the prosperity of the whole neighbourhood of Lyons.

* " White oils " are petroleum products, having a low flash-point, and "black oils " are those having a higher flash-point.

Gas Buoy Explosions at Calcutta

The following account of two serious explosions which have occurred in gas buoys at the Port of Calcutta is taken from the issue of May 5th of Lloyd's List. The incidents are very unfortunate, being attended by loss of life, and they indicate the responsibilities of port authorities in regard to gases of an explosive nature used for buoy lighting.

Explosions occurred recently in two gas buoys at Calcutta. On the first occasion the buoy had been lifted on to the deck of one of the Port Commissioners' vessels for overhaul. The buoy was of the " centre-pocket " type, in which the whole interior of the buoy is open to the collection of gas if there is any leakage, and which necessitates a man entering the body of the buoy to attend to the gas cylinders. After the manhole had been removed, an interval of five minutes elapsed before the gas mistry entered to remove the cylinders, and the man was inside about two minutes before the explosion occurred. The man was killed, and a second mistry who was standing by passing tools to him was badly burnt.

On the second occasion a motor launch was sent down to relight No. 2 Achipur Buoy. On arrival, it was found that there was no gas in the cylinders, and the work of re-charging the buoy was commenced. Subsequently an explosion of similar nature occurred, in which the man inside the buoy was killed and another man so badly burnt that he died the same day.

At a meeting of the Commissioners for the Port of Calcutta, it was reported that the Chief Inspector of Explosives was of the opinion that the safest course to adopt with buoys of the same type, of which there were eight on station, would be to tow them out to sea and to sink them by using explosives or else by gunfire. It was resolved that the possibility should be further examined of emptying the buoys without risk to life, but that no course should be adopted which in the opinion of the Chief Inspector of Explosives involved greater danger to life than towing the buoys out to sea and sinking them.

Correspondence

To the Editor of "The Dock and Harbour Authority"

Dear Sir,

I have read the article appearing in Lloyd's List of May 5th, headed " Explosions in Gas Buoys in Calcutta," to which you kindly called my attention and, in my opinion, it cannot fail to give the casual reader the impression that the explosions were due to some inherent defect in the System of Lighting employed.

Facts and material in our possession clearly demonstrate that the cause of the explosions was in no way whatever attributable to the system which, as I believe you know, has been generally adopted in this country by the Trinity House, the Admiralty and all the principal Port Authorities for the past twenty years, and throughout the Empire, without any accidents happening.

In our opinion the fault was entirely due to disregardful making up and installing pipe work and couplings, which work was carried out locally.

You are at liberty to make what use you like of the views expressed in this letter in your publication, but kindly bear in mind that the findings of the Government of India's Court of Enquiry have not yet been made public.

Yours sincerely,

W. J. CURTIS,

Managing Director,

The Gas Accumulator Co. (United Kingdom), Ltd.

Brentford, May 11th, 1939.

Book Review

British Shipping, by R. H. Thornton, pp. vii. + 304. Illustrated by photographs and diagrams. Price 7/6 net, 1939: Cambridge, at the University Press.

This volume forms one of a series on " English Institutions " issued under the general editorship of Lord Stamp. It constitutes a survey for the general reader of the growth and development of the British Mercantile Marine, accompanied by a readily comprehensible description of the various features of shipping routine. It is accordingly divided into two parts, the first of which, taking the chapter headings, deals in sequence with the Coming of Steam, the Steam Packet Company, Free Trade, Progress, the British Mercantile Marine and Economic Nationalism. The second part concerns itself with operative details; the Ship and its Job, Sea Carriage, Dockside, the Ship, the Office, Passengers, the Men, Watchkeepers, the Voyage, Competition and Combination and the Business of Shipowning.

It will be seen that a very considerable area of grounds is covered, historically, administratively and economically. As Lord Stamp remarks in his General Preface, shipping appeals to nearly every citizen on a variety of grounds. To some, there is the love of the sea and the craft which sail upon it. To others, there are the technical problems of navigation, seamanship, engine propulsion and the like. The services of others again are bound up in the administrative routine of transport and the handling of imports and exports. To every one, the subject is topical and interesting.

For such a variety of readers, the book makes a comprehensive and entertaining compendium, and if it does not quite fulfil the rôle of a text book, it is none the less effective in presenting the many-sided aspects of the shipping trade in an informative and instructive manner. The illustrations are artistic and effective and there is a useful index.

International Studies on Wave Force

By HERBERT CHATLEY, D.Sc.(Eng.),M.Inst.C.E.

(continued from page 196)

- MANOGRAPHE A QUARTZ -

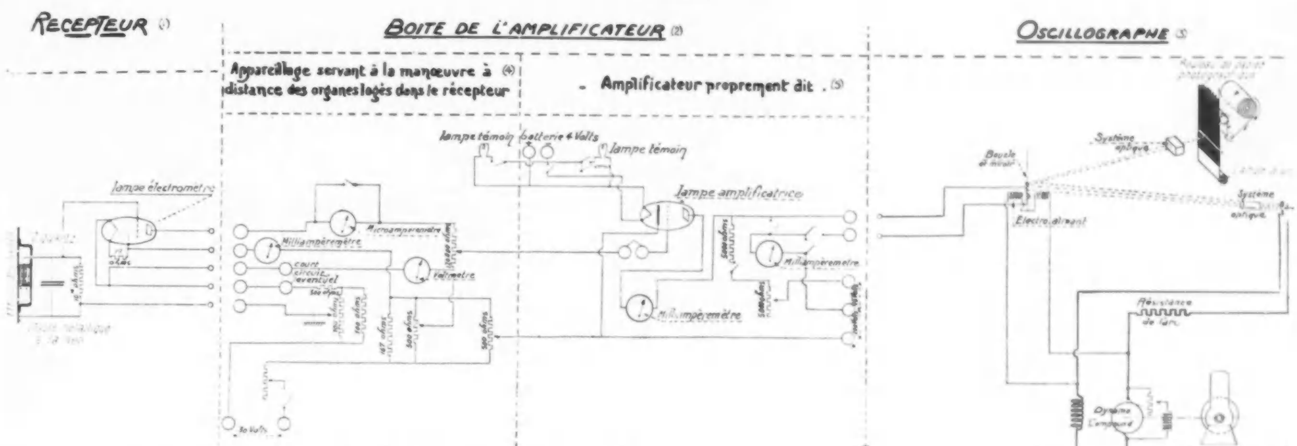


Fig. 10. Diagram of Apparatus

(1) Receiver (2) Amplifier Box (3) Oscillograph (4) Apparatus serving for operation at a distance of the elements in the receiver (5) Amplifier properly so called (6) Generator.

Electrical Apparatus

In order to reduce the time lag and so better to analyse the variation of force in the case of shocks and breakers, trials were made of an electro-magnetic device, it then being believed that piezo-electric methods would not be feasible in the conditions. The latter, however, proved more satisfactory than had been expected, and the electric apparatus was abandoned. For the sake of completeness, it is, however, described. The principle was that a receiving plate subject to the wave force and a restoring force, moves a small coil in the field of a larger coil, through which an alternating current (musical frequency) is passing. By two other coupled coils, the induced force in the small coil is nullified in the position of repose. When the small coil is moved, a current appears in it, which is amplified by thermionic valves and recorded on an oscillograph.

Alternatively, the small coil, when at rest, can be situated (axially) between two large coils carrying the same current (but in opposite directions), so that no current exists in the small coil when it is at rest, but developes as soon as it moves.

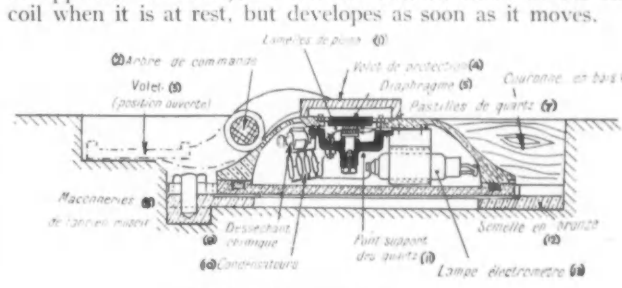


Fig. 11. Section of a Receiver

(1) Lead Plate (2) Control Shaft (3) Protective Cover (open position) (4) Cover (5) Diaphragm (6) Wooden Packing (7) Quartz Pastilles (8) Masonry of Old Pier Head (9) Chemical Drier (10) Condensers (11) Bridge supporting quartz (12) Bronze Frame (13) Electron Valve.

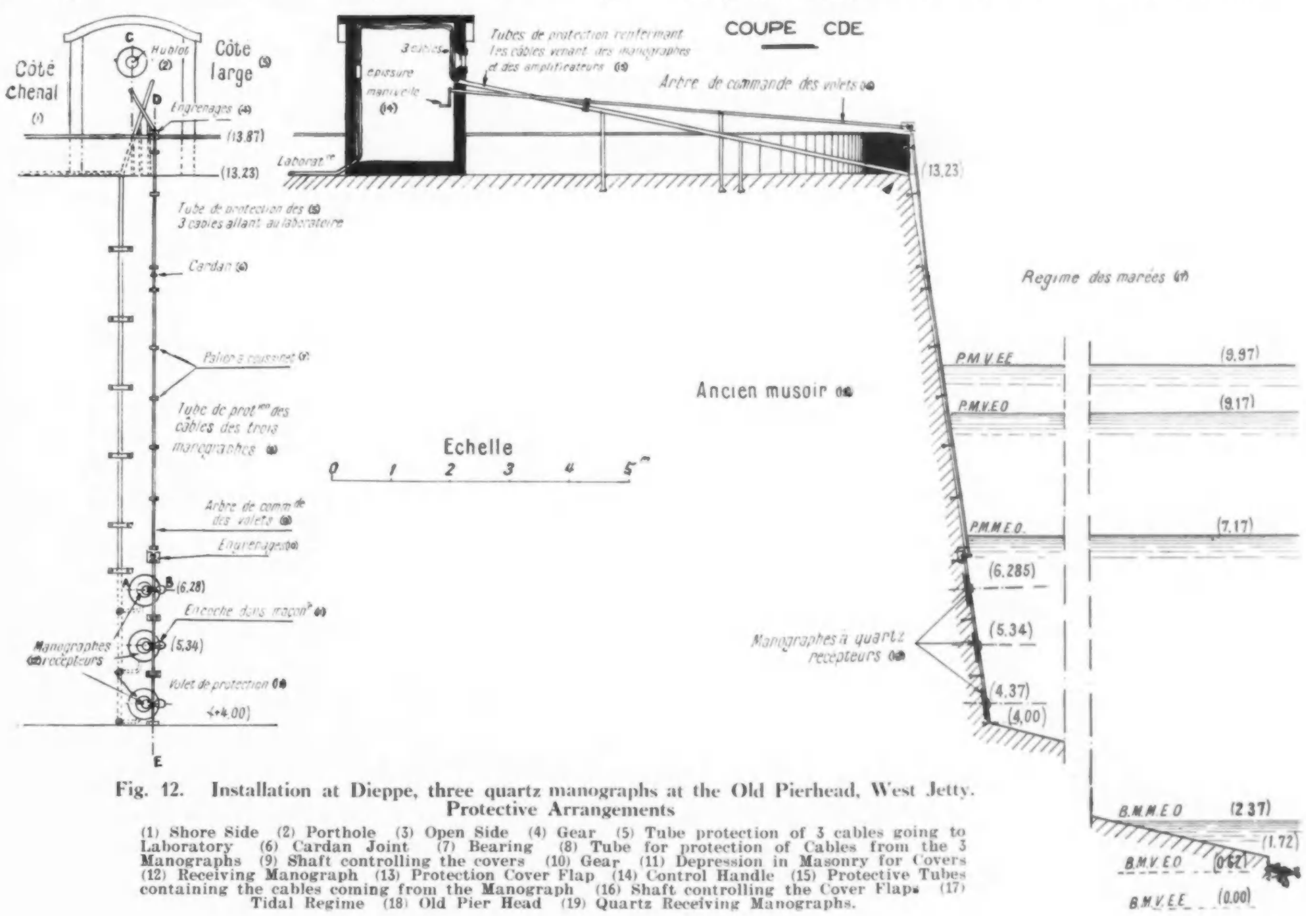


Fig. 12. Installation at Dieppe, three quartz manographs at the Old Pierhead, West Jetty. Protective Arrangements

(1) Shore Side (2) Porthole (3) Open Side (4) Gear (5) Tube protection of 3 cables going to Laboratory (6) Cardan Joint (7) Bearing (8) Tube for protection of Cables from the 3 Manographs (9) Shaft controlling the covers (10) Gear (11) Depression in Masonry for Covers (12) Receiving Manograph (13) Protection Cover Flap (14) Control Handle (15) Protective Tubes containing the cables coming from the Manograph (16) Shaft controlling the Cover Flaps (17) Tidal Regime (18) Old Pier Head (19) Quartz Receiving Manographs.

International Studies on Wave Force—continued

Details are given of the apparatus, but it is stated that it was very difficult to obtain exact compensation at the position of repose, which limited the practical value of the apparatus.

Mention is made of trials made in England of analogous apparatus, using a variation of electrical capacity instead of the induction.

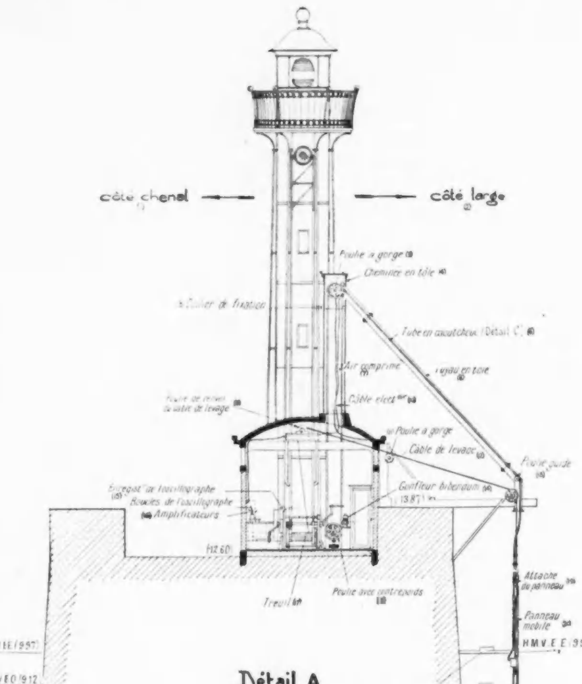


Fig. 13. Section of the whole Installation

(1) Shore Side (2) Open Side (3) Cleat (4) Metal Shaft (5) Steadying Ring (6) Rubber Tube (7) Compressed Air (8) Sheet Metal Tube (9) Pulley for Recovery of Lifting Cable (10) Electric Cable (11) Cleat (12) Lifting Cable (13) Guide Pulley (14) Compressor (15) Connections to Oscillograph (16) Amplifiers (17) Winch (18) Pulley and Counterweight (19) Buckle Connecting Panel (20) Movable Panel (21) Section (22) Struts Supporting Guides (23) Guide Bars (24) Electric Cable (25) Compressed Air Pipe (26) Vulcanized Rubber (27) Fabric (28) Sheet Rubber (29) Steel Channel (30) 4 Conduction Cables (31) Sheet Piles (32) Compressed Air Pipe (33) Electric Cable.

Piezo-Electric Apparatus

When a quartz crystal is compressed along an axis of crystallisation, the faces normal to that axis become charged. This charge can be measured by an electron valve, and by amplifying the variations in the current they can be recorded on an oscillograph.

The frequency of such an arrangement is very high, at least 1,000 oscillations per second, and it was therefore chosen at Dieppe and Havre for recording the very rapid variations of pressure in the shocks from breaking waves. It has also been used to record the slowly variable pressure of interference waves ("clapotis") against vertical walls at Algiers and Dieppe, as the flexible cable between the receiver and recorder readily allowed examination under water outside the wall.

The general arrangement is given in Fig. 10, and shows the receiver, amplifier and oscillograph and wiring.

The receivers can either be fixed or moveable.

Fig. 11 shows a Beaudoin receiver, including the quartz, electron valve, condenser and resistance, in a very thoroughly sealed box, including a chemical drier. A protective cover is provided, which can be swung back to the side when the receiver is in use. The pressure surface is a disc 0.06 metres in diameter, and it can bear a pressure of 100 metres of water.

In Algiers, the receivers are simply placed against the sea wall. At Dieppe they are set in flush with the wall of the jetty. Three circular holes have been sunk at 0.36, 1.34 and 2.28 metres from the foot of the wall, and bronze base rings are sealed into the masonry. The receiver boxes bolted therein come out to the face of the wall and all hollow spaces are filled with wooden packing, bolted down to the base rings.

The protective covers can be swung back to expose the receivers by a shaft operated from a control room when a reading is to be taken. The cables are passed through watertight tubes in the masonry and through a tunnel to the laboratory where, sheltered from all moisture, the amplifiers, oscillograph and chronographs are installed. The instrument is calibrated by a small hollow cap which can be bolted over the face of the receiver, to which a vertical pipe with a small hydraulic cylinder and piston, loaded with weights, can be applied.

The relation of the oscillograph readings to the applied loads is definitely linear.

Moveable Type

At the west jetty of the Port of Dieppe, is a vertical sea wall extending 4 metres below low-water level, the tide rising to 10 metres above that level, and a slipway was arranged on this wall to allow a sliding panel with the receiver to be installed. The slipway consists of channel irons riveted to steel sheet piles, which were driven in front of the sea wall.

The moveable panel consists of two plates 15 millimetres thick one plane and the other channel-shaped, filled with timber and pierced with three openings for a receiver. It is also fitted with pneumatic clamps capable of holding the panel at any desired level. Four recoil springs free the panel when the pneumatic pressure is released.

The pneumatic clamps, four in number, are rubber air vessels surrounded with rubbered fabric, 6 centimetres wide and each 100 centimetres long, giving a gripping force of 12 tons with a pressure of 5 atmospheres. A reinforced rubber air pipe serves these clamps and passes over a pulley (so as to exactly follow the motion of the panel) and leads to an air compressor. The electric cable from the receiver is placed inside the air pipe for protection, entering through special glands.

The lowest of the three orifices is that which is usually employed for the receiver.

The northern breakwater at Havre is placed N 19° 40′ E, and is thus exposed squarely to rollers or tempests from the West or North-west. Founded at a level + 1.50 metres on a heavy rock base, protected on the sea face with artificial blockwork, it clearly favours the breaking of rollers and lends itself to a procedure analogous to that at Dieppe.

Whereas, however, at Dieppe it has been endeavoured to investigate the diminution of the impulse with height, at Havre, where the surface exposed is very long, it has been hoped to acquire an idea of distribution of the effort not only with height, but also horizontally.

Five manographs have therefore been built into the face of the breakwater about 70 metres from its end between the levels + 5.00 and + 9.50, as shown in Fig. 14, three at the same level and two others above and below the central receiver.

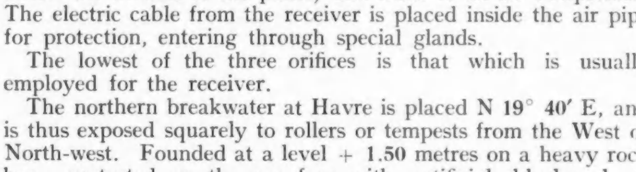


Fig. 14. Manograph Installations on the wall of the Breakwater at Havre

(1) Top of Parapet (2) Detail of Socket for Manographs (3) Square Groove (4) Socket of Manograph (5) First Ladder in the North Wall on external surface.

The observation station with its amplifiers, oscillographs and accumulators, has an electric-heating plant of 5 Kva with a thermostatic control at 18°C. The latter is stopped during observations to avoid induction effects. The accumulators are re-charged by a dynamo, which also serves the oscillograph.

An observer in a special projecting look-out in the breakwater telephones to the central station when the oscillograph is to be put into operation. He watches the size and speed of the rollers by a stadiometric telescope, using a beacon painted with green

International Studies on Wave Force—continued

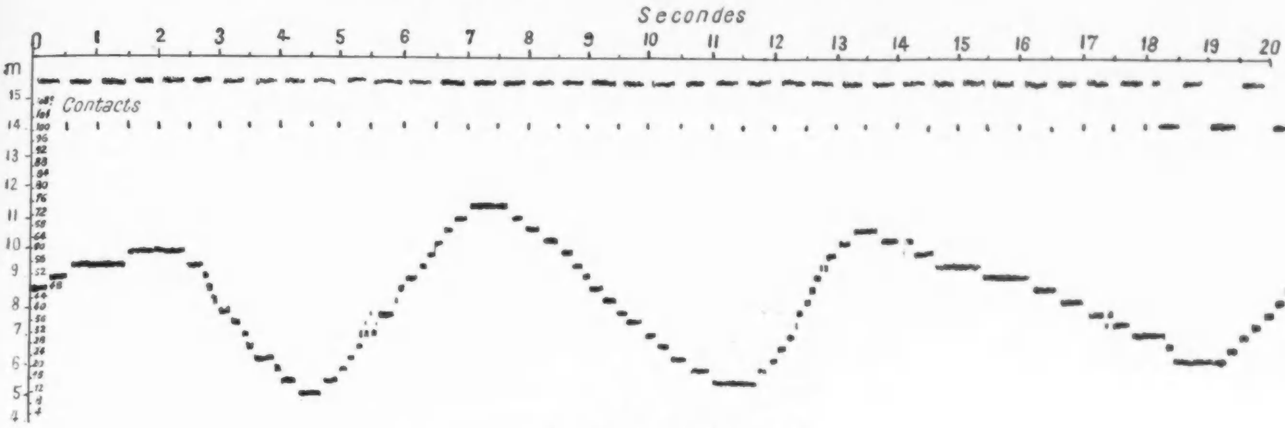


Fig. 15. Graphic Record

and yellow stripes, 500 metres away from the breakwater. This beacon, 16 metres high, is fixed to a 100-ton concrete block anchored on the sea bed at a level of −3.00 metres.

Mention is also made of optical apparatus which has been tried at Dieppe and Bizerta. In these, a plate receiver has a small mirror at the back which reflects a beam of light, emitted at some distance away, back to a cinematograph film. This type also has a very small lag.

The next section of this report deals with the measurement of waves. It is stated that, as far as the authors know, the first exact study of the form of a face roller was made at Heligoland in 1911. The first systematic study of waves (at Genoa, Algiers and Dieppe) was made by telescopic observations of a float, but the disturbances caused by the anchorage, capsizings due to wind and wave and the obscurity due to spray at Dieppe, led to the use of two fixed tubes fixed in concrete blocks. These were set 50 metres apart, painted in half-metre bands of black and yellow. Thrice a day the height (2h) was observed directly by counting the number of rings covered at the top of the waves. The angle α of the direction of the crests with the alignment of the beacons was read on a circumferentor; the time t required for a wave to pass from one beacon to the other and the time 2T separating the passing of two consecutive waves at one beacon were measured by a chronometer.

Calculation gave the following:

$$V=\frac{50 \text{ Sin } \alpha}{t}$$

and the length of the wave

$$2L=2TV$$

A tide-pole recorded continually the still water level in a sheltered part of the port, near the jetty.

At Algiers, two cinematograph machines took views, which allowed successive stereo-photographs to be drawn, but this procedure is very costly.

At Havre, as already mentioned, a beacon painted with bands was embedded in a mass of concrete.

Details are then given of a " Kymatograph " as used at Dieppe and Algiers for the measurement of the " clapotis " (enhanced or superposed wave). This consisted of a whole series of contacts (sparking plugs). When these were immersed, the passing current operated a magnet, closing a relay circuit connected through a Wheatstone bridge to an oscillograph recording on a chronograph drum.

Details are then given as to the combined observation of wave-efforts and wave dimensions at Dieppe and reduction of the readings to the proper zeros.

A summary of the theories and formulæ as to waves next follows, based on the work of Leonardo da Vinci, Newton, Lagrange, Gerstner, Poisson, Bouissinesq, Sainflou, Gourret and Larras.

The formulæ of Sainflou for the superposed wave are adopted, and it is shown how the pressures, during the cycle, may be computed step by step.

In January, 1937, by means of the kymatograph (wave recorder), differential manograph and exploring quartz manograph a series of observations were taken during a N.E. gale, which have been compared with the theoretical values.

A summary of the principal results from the experimental diagrams and theoretical graphs is given in Fig. 18. This refers only to the maximum and minimum effects: the variations of pressure are referred to the unit of deviation from mean level along the breakwater (thus practically eliminating the irregularity in the height of successive waves). Facing the diagrammatic section of the jetty are shown; in the ordinates, the level of the manograph; in the abscissae, on the right, the quotient of the maximum increase of head above the equilibrium pressure (" over-pressure ") by the maximum elevation of the water level above the still water level (rise); in the abscissae, on the left, the quotient of the maximum reduction of head below the equilibrium pressure (" under-pressure ") by the maximum lowering of the water level below the still water level. The experimental points are scattered around but quite near to the continuous line, which represents the calculated values.

The levels shown are:—

	Metres
Extraordinary high water	9.97
Normal spring high water	9.17
Mean elevation of neap high water	7.12
„ neap low water	2.30
Normal spring low water	0.62
Extraordinary low water	0.00

The breaking of waves on a sloping shore is next discussed. The conditions are quite different from those of free or squarely reflected waves, and as was shown in Airy in 1850, the undulatory movements of ordinary waves are incompatible with a variable depth.

It is agreed that " breaking " occurs on all shores making an angle with the horizontal less than 20°; the depth H′ at which

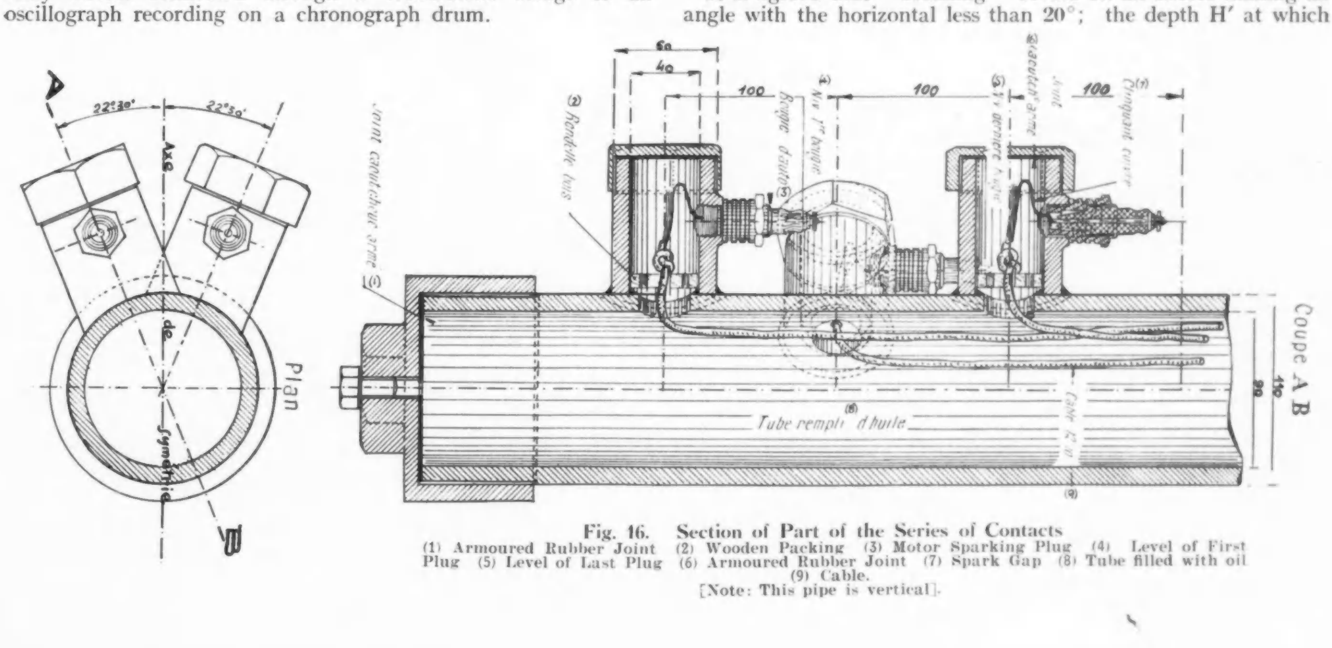


Fig. 16. Section of Part of the Series of Contacts
(1) Armoured Rubber Joint (2) Wooden Packing (3) Motor Sparking Plug (4) Level of First Plug (5) Level of Last Plug (6) Armoured Rubber Joint (7) Spark Gap (8) Tube filled with oil (9) Cable.
[Note: This pipe is vertical].

International Studies on Wave Force—continued

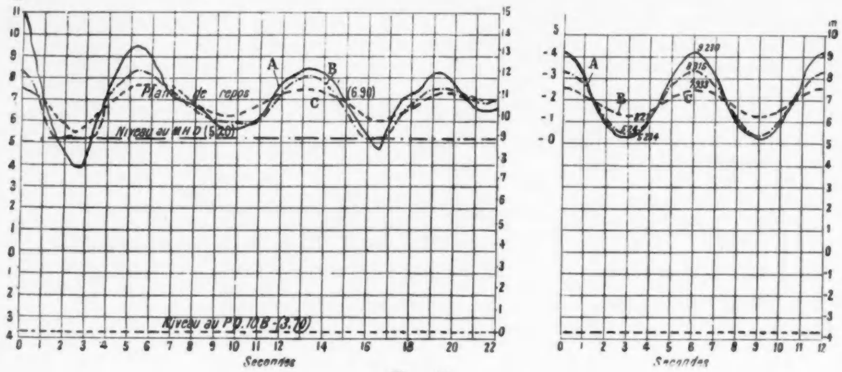


Fig. 17

7th January, 1937, 19h. 22m. Characteristic of Wave: Length 2L eq. 40m. Height 2h. eq. 4m. Speed V eq. 6.70 m. per second. A. Height of Water recorded by Kymatograph. B. Pressure recorded by Hydraulic Differential Manograph. C. Pressure recorded by Quartz.

the waves of a roller turn over is not yet calculable, and the critical value of the angle formed in that place by the two tangents to the wave crest is the subject of controversy. The

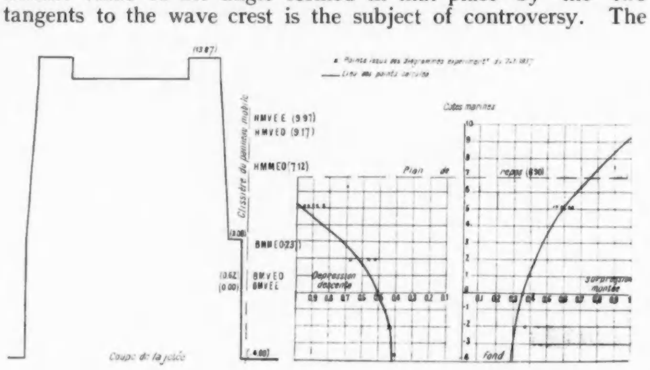


Fig. 18

height of the wave having a value 2h′ greater than 2h (the height in deep water), Stevenson found in 1870, at Wick Bay, that H′/h′ varied from 2 to 5, and Gaillard reports observations made in 1902 on the great American lakes, where this quotient had a mean value of 3.34. Some experiments with a model, described by Larras (see Dock and Harbour Authority, May, 1938) only indicate that, as might be expected, breaking is hastened by the roughness of the bed, and that the wave crests exceed the still water level by 1.5h′, their troughs remaining 0.5h′ below that level.

Manographic and Cinematographic Records

The favourable conditions at the old pier head of the West Jetty at Dieppe have allowed records to be made of the shock due to breakwaters and flying spray.

After a gentle chalk slope, the rollers encounter a gravel shore, followed by a 1 in 5 rubble mound (levels + 1.72 to 4.00) and then a wall with a slight batter between levels + 4.00 and 13.00. Mean low water is at + 1.50 and half tide at + 5.00. Three quartz manographs are fixed flush in the sea wall at levels + 4.37, + 5.34 and + 6.285; the amplifiers and recording oscillograph are sheltered 300 metres away in a laboratory.

In a cabin shelter on the head of a timber jetty extension an ordinary cinematograph apparatus is installed facing the old pier head. In the field of the objective are two scales, sub-divided into metre lengths, painted alternately black and white. One of these is horizontal and bolted against the parapet of the timber jetty and continued by means of regularly-spaced posts. This allows the propagation of the wave to be followed. The other scale is set against the old pier head and reproduces the joints in the masonry in order to indicate the height 2h′ and the outline of the spray. Pictures are taken with an exposure of 1/200 second and at intervals of 1/24 second.

A special synchronizing circuit connects a lamp in the camera with a spot in the oscillograph.

A controller, near the camera, regulates all the circuits and instruments, chooses suitable waves, starts the apparatus, and stops it after about three seconds' run.

Some waves of identical appearance break unequally. Some are checked by the flow of those preceding; others strike the wall obliquely, or at a distance from the recorders; some only meet well-exposed mound, and roll over in a volute to the foot of the wall enclosing a considerable amount of air and smack against the face in front of the receivers. The proportion of interesting records never exceeds 5%.

Fig. 19 shows simultaneous observations of wave speed, manograph readings of wave pressure at three levels, and cinematograph views of the waves.

A table of results shows the following characteristic figures:—

Length of wave—40 to 45 metres.
Free height of wave—1.5 to 2.5 metres.
Speed „ „ —5.5 to 6.0 metres per second.
Breaking height—2.0 to 3.5 metres.
Horizontal velocity at breaking—6.5 to 12.0 metres per second.
Initial vertical velocity (spray)—25 to 77.0 metres per second.
Pressure at 0.35 metres from foot of jetty—16 to 69 tons per sq. metre.
at 1.35 metres—3 to 31 tons per sq. metre.
at 2.35 metres—0 to 22 tons per sq. metre.

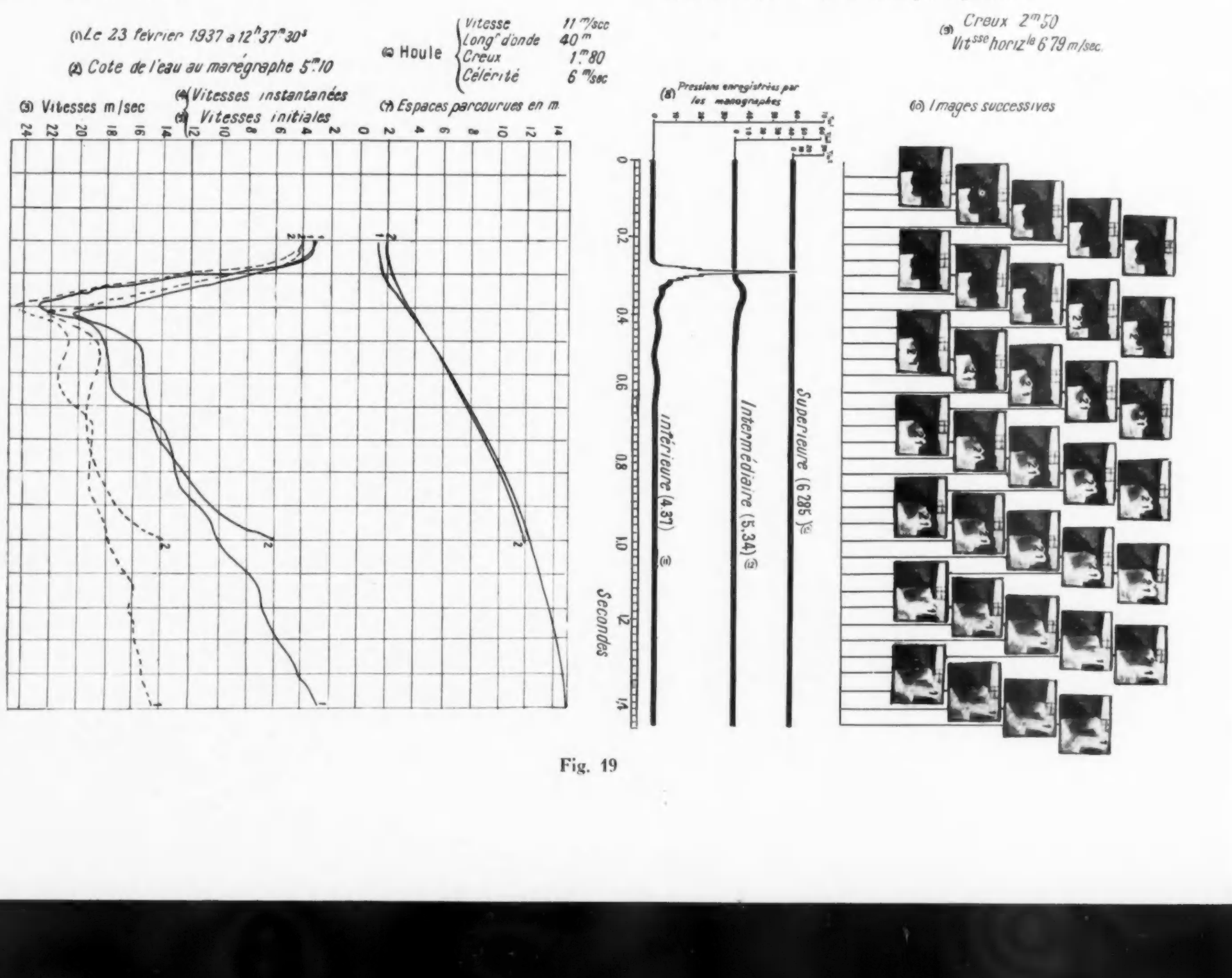


Fig. 19

International Studies on Wave Force—continued

The largest waves do not give the most violent shocks, but sometimes all three manographs give synchronous pressures lasting some tenths of a second, all the water against the jetty oscillating at the one time. The frequency seems to depend on the quantity of water in the wave. The uppermost manograph usually gave very small readings, the breaker rising up the wall with only slight support from it. Sometimes the middle manograph read higher than the bottom one. The shock (0 to 70 tons per sq. metre) only lasted about 0.005 second, and its accurate registration is a testimony to the value of the piezo-electric method.

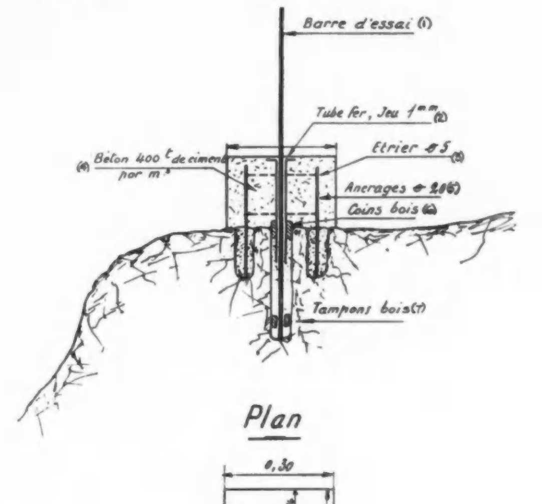


Fig. 20. Setting of Trial Bars

(1) Trial Bar (2) Iron Tube 1 m.m. play (3) Tie Rods 5 m.m. diameter (4) Concrete Block (5) Anchor Rods 20 m.m. diameter (6) Wooden Wedges (7) Wooden Plugs (8) Tie Rods 5 m.m. diameter (9) Anchor Rods 20 m.m. diameter (10) Holes 50 m.m.

The spray velocities indicated by the cinematograph films are surprisingly high, quite difficult to reconcile with the orbital speeds of the waves (of the order of 1 or 2 metres per second) or their reflections. It is suggested that these high velocities are due to compressed air, produced when the waves break in a re-entrant angle of the masonry. Spray has been seen to rise to a height of 25 metres at Dieppe, and at Ushant it has exceeded 40 metres, for analogous reasons.

The fifth section of the report deals with non-recording apparatus for measuring wave force, including distortion tests on rods, tubes, reinforced concrete turrets at Finisterre, the shifting of blocks and dents in Brinnel apparatus.

In regard to the first group, it is noted that the test pieces were set up on rock surfaces or on large inclined surfaces where the waves broke freely without mutual collision or reaction from a vertical face. The maximum forces were then due to sudden contact of masses of water thrown horizontally by the breaking. Fire hoses show that sudden impingement of a current will give forces 35% or so greater than those due to the steady stream.

It is suggested that such test pieces are incapable of indicating the much greater and more dangerous pressures which may occur quite close at hand in irregularities of the surface.

On the rock shore by the lighthouse at Ushant, and also at Cat Rock, near Raz-de-Sein, rows of iron rods have been set up at levels + 2.00, + 5.20 and + 5.80 (at Ushant) and + 8.00 (at Cat Rock). The sea rises to + 8.00 at Ushant and + 7.00 at Raz-de-Sein.

Each row consisted of five rods 10, 12, 14, 16 and 18 millimetres in diameter respectively. Each rod was one metre long, 0.30 metres being bedded in the rock and 0.20 metres in a tube set in a concrete block, so that the rod projected 0.50 metres.

The object of the tube and concrete block was to improve the setting of the rods and also keep them clear of the slower water checked by contact with the rocks.

Experiment showed that no rod was ever bent without all the smaller ones being bent also, and that there was a good agreement in results between the two sites.

Rods up to 14 millimetres were rather often bent, corresponding to an uniform effort of about one kilogramme per sq. centimetre or speed of about nine metres per second. A 16-millimetre rod was bent, about high-water level, in 1930, corresponding to an impulsive force of about 1.6 Kg/sq. cm.

It is noted that this confirms the experience with iron rails, etc., at lighthouses, which, below certain levels, must be some 20 millimetres in diameter, if they are not to be bent or broken by the waves.

It had been hoped in 1932-3 to make experiments on breakers with surfaces of about one sq. metre, but to demolish a solid turret one metre diameter by wave force would involve a height of about five metres, over which the distribution of the pressure would be uncertain. Moreover, it would be difficult to distinguish between shearing and overturning effects. A cylindrical concrete turret one metre diameter and one metre high, was therefore designed to fit on a concrete base 0.20 metres height, a tenon piece rising from the latter into a mortice in the turret. Five centimetre play in the mortice was allowed on the wave-ward side, and a tie-rod in a tube prevented the block from overturning. The tenon was tied horizontally (away from the waves) to the block with two light metal rods. These were stretched when the turret was shifted, and the force required to cause this stretch (and to overcome the friction of the turret on its base) indicated the wave force.

Forces of about 12 tons per sq. metre were indicated by this apparatus, at Ushant and Sein.

Metal tubes (up to 114 millimetres diameter) were also tried, and indicate forces up to 3.37 tons per sq. metre.

A description then follows of six blocks hinged at the rear lower edge, at a level of + 4.70 at Dieppe. These blocks were one metre long, 0.50 metres high, and from 0.88 to 2.40 wide, requiring static uniform force pressures of from 2.75 to 24.3 tons per sq. metre to overturn them. A knife edge working against a leaden surface records the tendency to move.

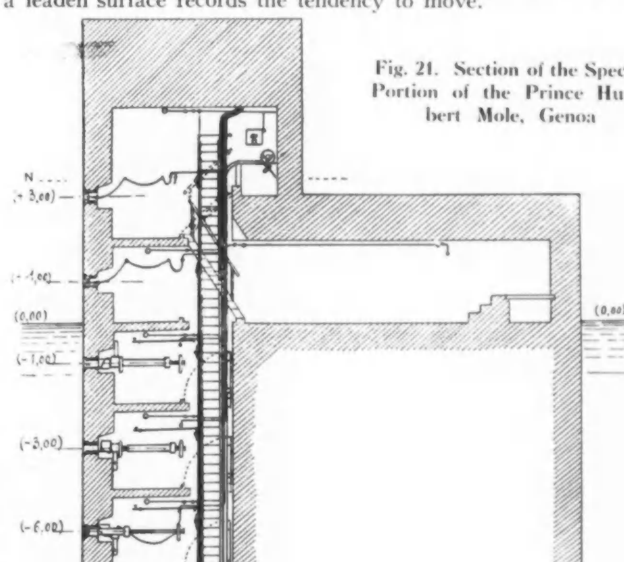


Fig. 21. Section of the Special Portion of the Prince Humbert Mole, Genoa

Block No. 1 has frequently moved. Block No. 2 rarely moved (twice in 1934). Blocks No. 3 and No. 4 slightly moved during very severe storms, indicating pressure of 12 tons per sq. metre as the probable maximum effort of waves three metres high and 40 metres long. The defects (due to neglect of rear under-pressures, etc.), of these observations are discussed.

Receivers working with tin blocks against a steel ball, on the Brinnel hardness principle, did not prove satisfactory, owing to the enlargement of the depression in the tin by successive shocks and the strains caused by fitting.

The report concludes with a note on some recent experiments made at Algiers, Genoa, Spain and in Great Britain. The Genoa apparatus is very elaborate, using hydraulic dynamometers with elastic diaphragm receivers, behind which is a water column, leading to a mercury manometer, into which dips a platinum spiral. The variations of electric resistance of the latter are recorded on an oscillograph. By means of pistons and glands, the dynamometers can be withdrawn without admitting the sea into the access chamber.

Notes of the Month

Philippine Ports Open to Shipping.

H.M. Consul-General at Manila has reported that the ports of Siasi and Batobato, both in the Sula archipelago, and Malanga, in the province of Zamboanga, island of Mindanao, were opened to overseas shipping at the beginning of last month. The commissioning of these three ports increases the number of Philippine overseas ports from 12 to 15.

Decree Approved for the Port of Leghorn.

The Italian House of Fascisti and Corporations, as the Italian Parliament is called, has approved a decree authorising the transfer of the areas available in the industrial zone of the Port of Leghorn to the Societa Anonima Porto Industriale di Livorno. This is regarded as the first step towards the creation of a Port Authority at Leghorn, similar to those at Naples, Venice and Trieste.

Harbour Repairs at Girvan.

The Town Council's scheme for repairs to Girvan Harbour is to be put in hand in the near future. The Walk, adjoining the Knockaushion Gardens is considered unsafe, and the harbour wall has been in a state of disrepair for some time. Preparations are in hand for the work, which entails pile driving over an area of about 100 yards, and is expected to cost a total of approximately £4,000. The Walk will be closed until the scheme is completed.

Increased Shipping at Stockholm Free Port.

Shipping at the Stockholm Free Port during 1938 numbered 5,399 vessels, totalling 2,720,000 tons, compared with 4,828 vessels, totalling 2,493,000 tons, during 1937, an increase in tonnage of 8.3%. The storage revenues of the Free Port Company amounted to 905,000 kr., an increase of 6%. The harbour dues for ships totalled 110,000 kr., an increase of 2.3%, and the Customs revenues collected increased by over 2,000,000 kr. to 22,370,000 kr.

Queen's Dock Reopened at Whitehaven.

Following the completion of an improvement scheme costing approximately £30,000, the Queen's Dock, Whitehaven, was reopened early last month. The scheme, which necessitated the closing down of the port for a period of about 14 months, was financed by the Special Areas Commissioner, who granted £10,000 and lent the Harbour Commissioners the balance at a low rate of interest. As the local coal mines are now working at full pressure, and facilities are available for docking vessels of up to 4,000 tons, a new era of industrial prosperity for the town is expected.

Extensions at the Port of Assab.

It is reported that improvements are being undertaken by the Italian authorities at the Port of Assab, Eritrea. The developments include the construction of two wharves of about 150 metres (492-ft.) in length, capable of accommodating four deep-draft vessels simultaneously, and equipped with modern loading and unloading plant. Protective moles extending for more than a kilometre, are also to be constructed, and the basin is to be dredged to a depth of from 10 to 12 metres (33 to 39-ft.). It is expected that the work will be completed by the end of next year.

The St. Lawrence Ship Channel.

When the estimates were recently submitted to the Canadian Parliament, it was stated that the 35-ft. channel in the St. Lawrence River to Montreal would be completed by 1943, at an estimated cost of about $80,000,000. The current estimates include an item of approximately $3,230,000 for the dredging in the channel, and the final stage of the scheme comprises work between Three Rivers and Montreal, a distance of over 62 miles. When completed, the channel will accommodate any class of vessel trading to Montreal, except the "Empress of Britain," whose draft of 33-ft. would leave too small a margin for safe navigation.

New Lithuanian Free Port.

In an official notice issued after the signing of the German-Lithuanian trade treaty, it is announced that Germany intends to create a new free port for the benefit of Lithuania, situated about two miles to the South of Memel, which, formerly Lithuania's sole port, was recently annexed to the Reich. A special commission of the joint nationalities has been set up to work out details of the scheme, which it is anticipated will be in a condition to function almost immediately. In addition, Lithuania is to have two free port zones in the harbour of Memel, so as to enable its transit trade to be carried on without international friction.

Wreck Marking Buoy for Port of Bombay.

The Trustees of the Port of Bombay recently voted the sum of Rs. 16,660 for a new Wreck Marking Buoy, and alterations to existing buoys and beacons in the Bombay Harbour to conform with the system of maritime buoyage proposed under an International Agreement, which has been ratified on behalf of India.

Waterford Harbour Annual Statement.

An increase of over £14,000 in payments over receipts was shown in the annual statement submitted to the Waterford Harbour Board at a statutory meeting held early last month. Mr. J. A. Nolan, the Chairman, said that the increase was mainly due to the cost of the Commissioners' new cold storage premises, which was met out of current revenue. Receipts decreased by nearly £1,000, compared with 1937.

Proposed Australian Dry Dock.

Brigadier Street, the Australian Minister of Defence, in a recent statement to the press, announced that on the recommendation of the Admiralty, Sir Leopold Savile has been engaged to visit Australia immediately to advise the Commonwealth Government concerning the provision of a dry dock to accommodate capital ships. Sir Leopold, who was formerly Civil Engineer-in-Chief to the Admiralty, will submit designs and plans and an estimate of the cost involved.

East Wharf to be Replaced at Singapore Harbour.

Work on the rebuilding of the East Wharf at Singapore Harbour is to be undertaken in the near future. The present wooden structure will be replaced by one of the same size and shape constructed in reinforced concrete. During the rebuilding operations, which are expected to take 2½ years, half the wharf will be closed at one time so as to minimise inconvenience to shipping. The work, which it is estimated will cost $1,000,000, will be executed by the Harbour Board's engineering staff.

Dry Dock to be Widened at Newport.

It is reported that Messrs. C. H. Bailey, Ltd., ship repairers and dry-dock owners, have obtained quotations for widening their dry dock at Newport to 64-ft. and lengthening it to 452-ft. The work involved will necessitate the closing of the dry dock for a period of about two months, and a convenient time for this will be chosen in the spring of 1940. On completion, the dry dock will be able to dock a ship of 60-ft. beam, and still have sufficient room for working. It is understood that work will be commenced at an early date.

United Kingdom Pilots' Association Annual Conference.

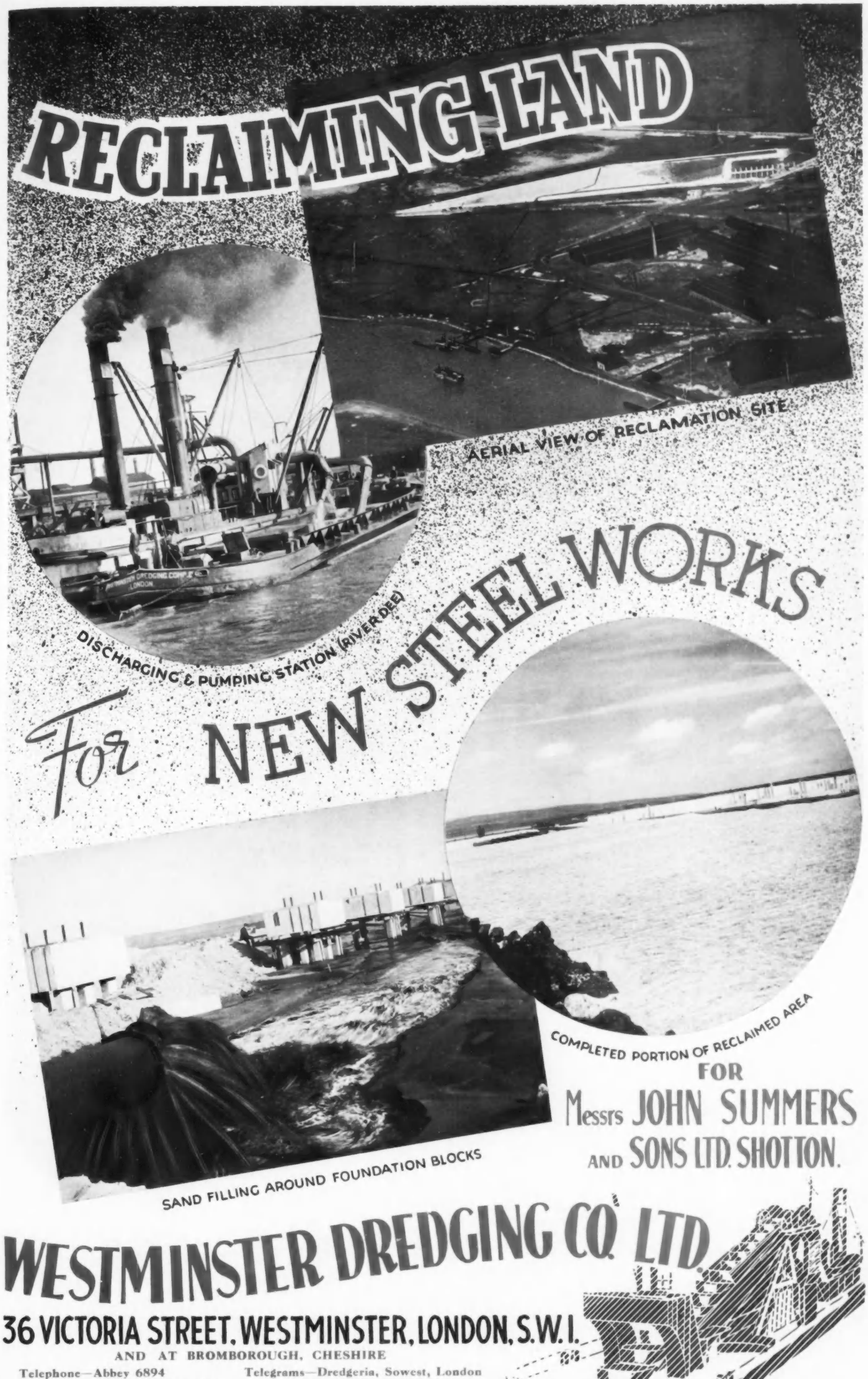
The 1939 annual conference of the United Kingdom Pilots' Association will be held at the Old Assembly Rooms, Westgate Road, Newcastle-upon-Tyne, from June 13th to June 16th. The conference agenda contain two resolutions, of which notice has been given. Liverpool pilots will move "That the dual penalties to which a pilot is liable under the Pilotage Act and By-laws made under the Act are contrary to the principles of natural justice, and call for an amendment of the law"; Swansea pilots will move "That the United Kingdom Pilots' Association be asked to review the constitution of pilotage authorities throughout the kingdom, with a view to their reconstruction and a more equitable distribution of their interests therein."

Spanish Harbours to be Rehabilitated.

Large-scale plans of reconstruction are announced in new decrees signed by General Franco, with the object of improving the communications and harbours of Spain. The programme includes the provision of important waterworks in various parts of the country; the reconstruction and extension of the Port of Los Pasajes, near San Sebastian, including the provision of new lighting, enlarged docks, dredgers, tugs, derricks and cranes; improvement and modernisation of the ports of San Sebastian and Fuenterrabia; and the construction of new lighthouses. It is stated that this programme is only the first step in a large-scale long-term scheme, and that further ambitious plans will be announced.

Contract Placed for Part of Melbourne Port Scheme.

The contract for the excavation of the site of the new Appleton Dock, adjacent to Victoria Dock, Melbourne, has been placed by the Melbourne Harbour Trust Commissioners with the Netherlands Harbour Works Company, Amsterdam. The dock is the first part of the Commissioners' plan for port improvement, which will ultimately provide accommodation for 21 large ocean-going vessels, and is expected to cost a total of £3,500,000. Excavation for the new dock will be made to a depth of 32-ft. at low water, and this part of the work will cost £65,000.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PORT ÉDOUARD HERRIOT

AT LYONS

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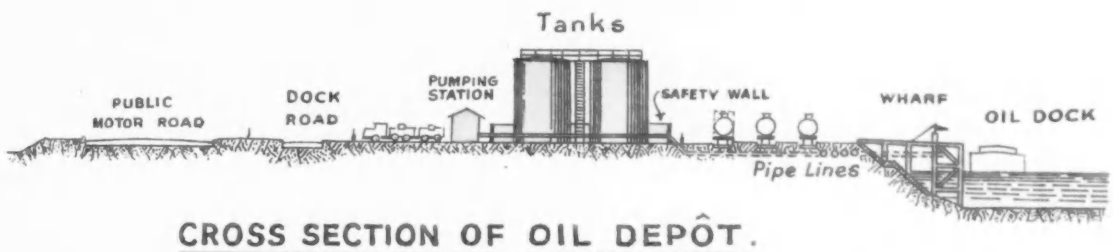
M. COUTEAUD, INGÉNIEUR DES PONTS ET CHAUSSÉES, CHEF DU SERVICE DE LA NAVIGATION À LA COMP^GNIE NAT. DU RHÔNE.



CROSS SECTION OF OIL DEPÔT.

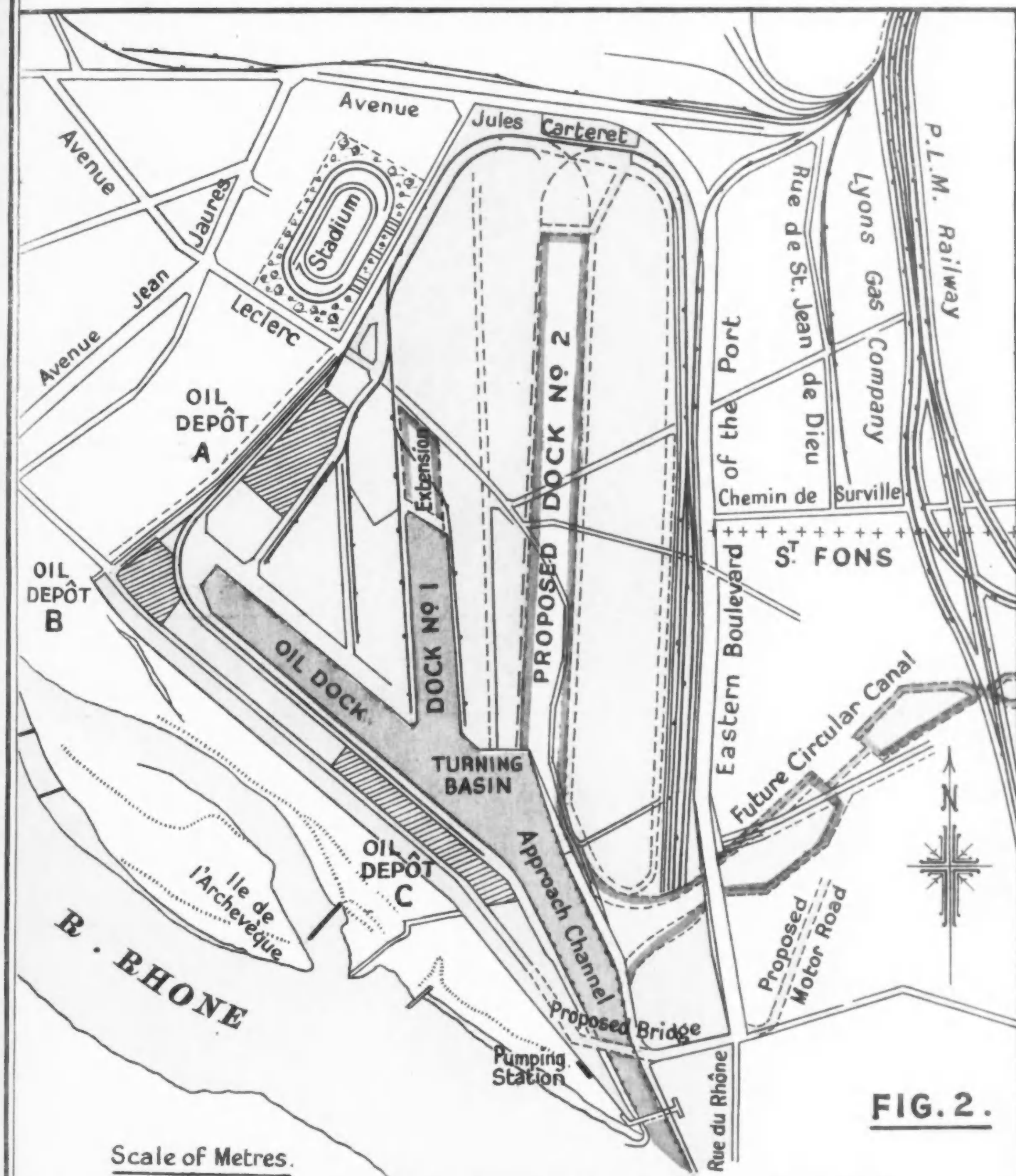
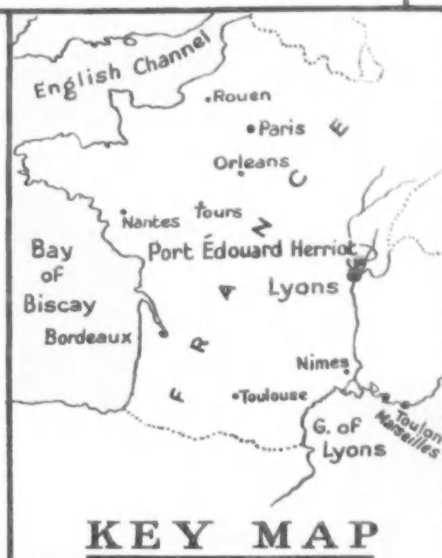


FIG. 2.

GENERAL PLAN OF THE PORT.



KEY MAP

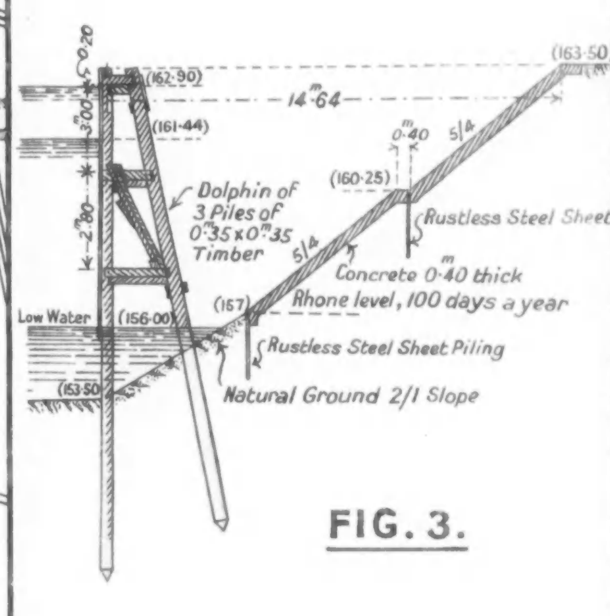


FIG. 3.

CROSS SECTION OF REVETMEN

WARD & FOXLOW, LTD. LITHO. HARCOURT ST. LONDON W.1

HERRIOT

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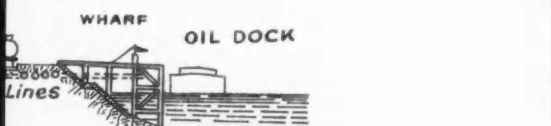
R TECHNIQUE DE LA COMPGNIE NAT. DU RHÔNE.

A NAVIGATION À LA COMPGNIE NAT. DU RHÔNE.



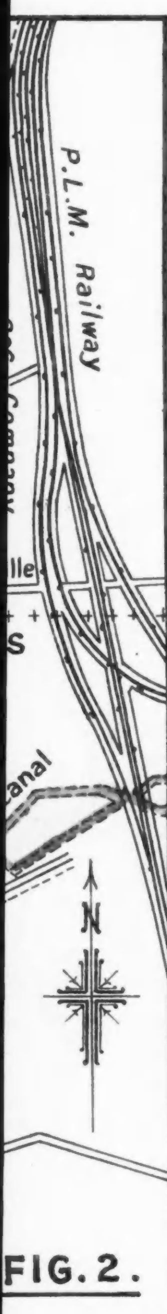


FIG. 2.

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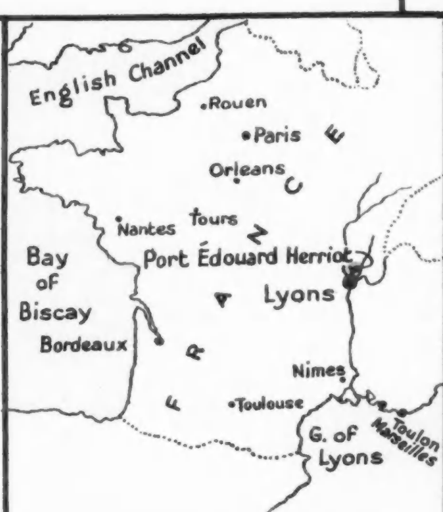

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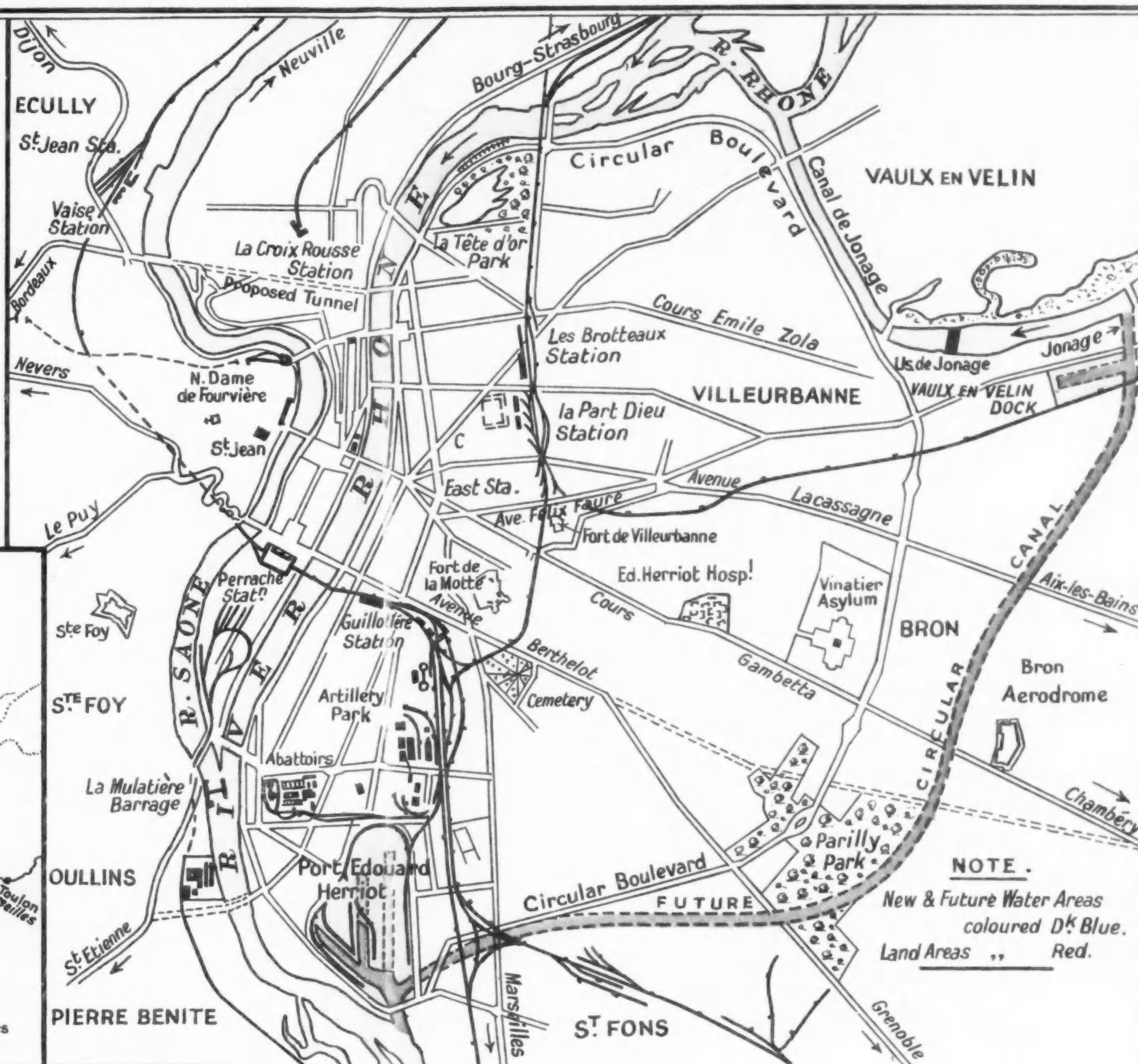

SITE PLAN OF THE PORT.

Scale.

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FIG. 1.

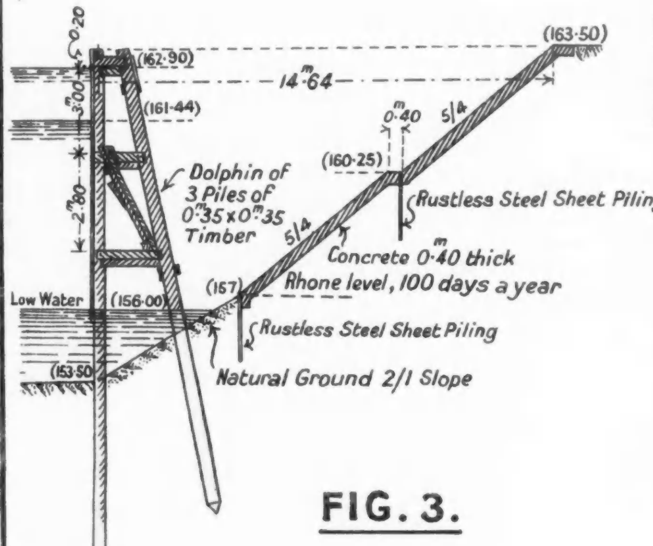

FIG. 3.

CROSS SECTION OF REVETMENT.

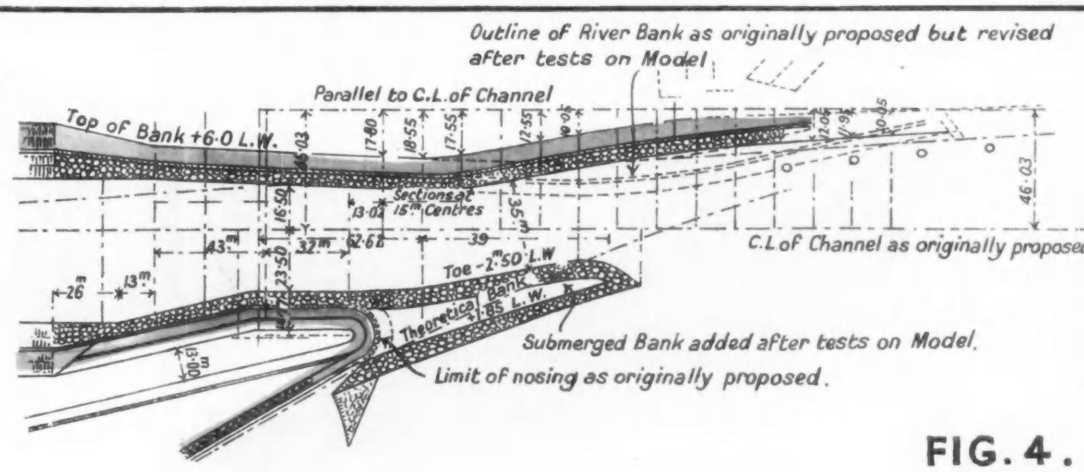

FIG. 4.

PROPOSED ENTRANCE TO THE PORT.

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Sextant-Graph Plotting

By Lieut.-Commdr. D. H. MACMILLAN, R.N.R. (Retd.), Master Mariner (Extra)*

Port Hydrographers have every reason to be grateful for the paper on Sextant Charts published in the April issue of this Journal by permission of Mr. L. D. Shuman, Principal Engineer of the War Department—U.S.A.—and the writer desires to express his thanks for the notice which this gentleman has been kind enough to give to a previous paper (published in this Journal, August, 1938), dealing with the subject.

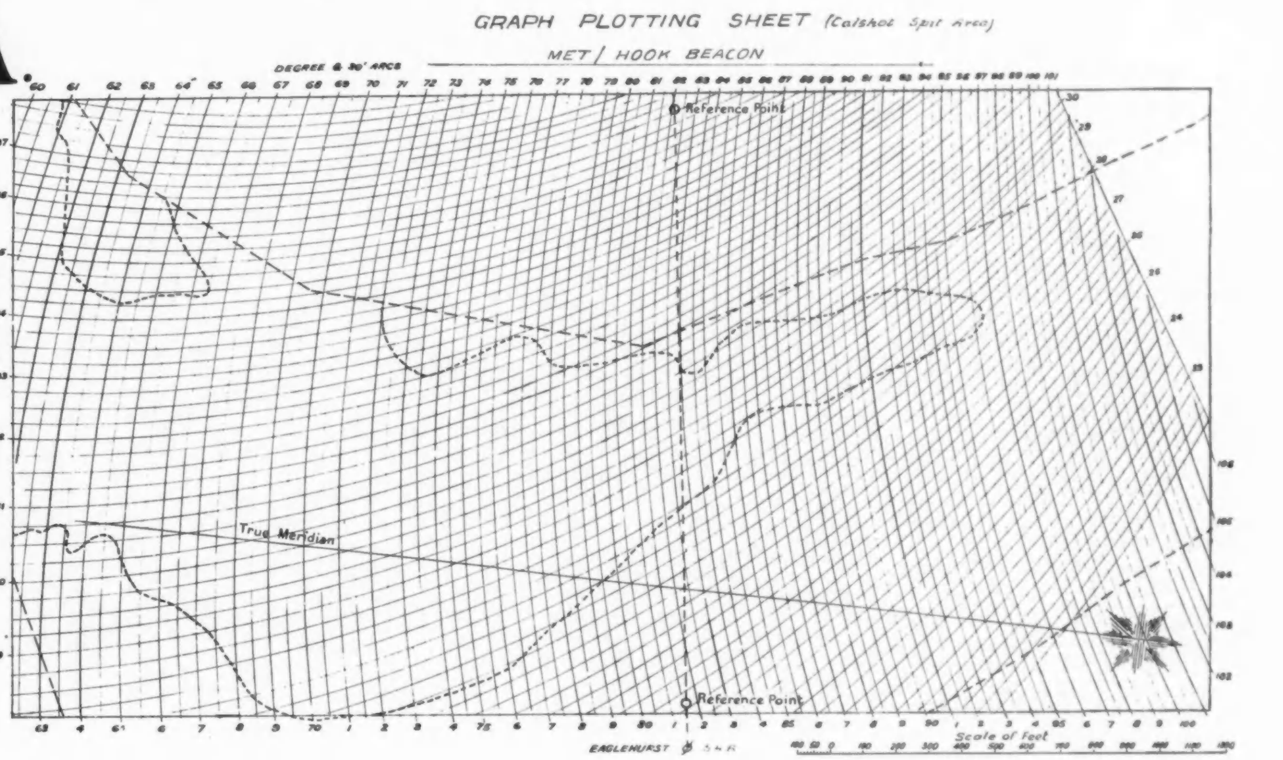
It is interesting to note the parallel development of this technique in America, as the writer has independently developed and used an almost precisely similar system during the last six years. The paper referred to is an excellent basis for further research into this very fruitful field of progress.

(a) Difficulty of employing a large enough scale when one is limited by a reasonable size Station Pointer (the instrument in common use for plotting " three point " fixes). As in some estuaries the shore " points " are fairly remote from those portions of the approach requiring close and frequent survey, it follows that a very large Station Pointer is impractical afloat, and thus the fixes would require to be cumbrously replotted ashore.

(b) Even if a Station Pointer of a large enough size to accommodate the scale of the " working sheet " used afloat is employed, the time taken to set the instrument to sextant angles, and adjust it over the " points," increases the interval between the fixes, and thus the Surveyor frequently misses important contours and is not free enough to " conn ship."

(c) With the almost inevitable distortion—common to paper plotting sheets of such size—the resulting plot will be seriously enough displaced in some cases as to misrepresent contours and shoals with reference to the " points."

A.



The new methods of sounding, by Sonic Echo, demand a more rapid and simple method of plotting " fixes " afloat if the higher speeds of survey now available are to be utilised to the full. From many quarters the writer, when discussing Echo Sounding, has heard the complaint, " we *know* we can get soundings at, say, 8 knots, but we simply must reduce speed to plot the fixes closely enough by Station Pointer methods! "

This is a very real cause of slowing down survey work when one remembers the following features:—

(a) A survey launch at, say, 8 knots, travels 800-ft. per minute.

(b) It takes about 30 seconds to observe angles, read sextants, set station pointer and plot position, working at top speed.

(c) One minute intervals give 800-ft. intervals between plotted fixes, which are none too short for detail in large scale estuarial work.

The Surveyor, under such onerous conditions, would have practically no time free to " conn " his ship, and certainly none to fix and plot upon important contours as indicated by the Echo Record. He would, of course, ease speed to about 4-5 knots, and heave a sigh of heartfelt relief, as the writer has done in similar circumstances.

This problem with others is solved by Graph-plotting, and it is now proposed to deal with some of the practical difficulties and their solution by this technique.

The Graph method of plotting the track of a vessel by simultaneous angles, particularly whilst surveying on large-scale work, was independently evolved by the writer on account of the difficulties usually experienced, which may be set out as follows:—

(d) If a mistake in reading sextant setting, station pointers, or adjusting the latter over " points " is made, this does not become evident until most of the process is gone through, and the station pointer readings are checked. This is a serious cause of inaccuracy, uncertainty, and a waste of time into the bargain.

(e) When the "three point fix" is weak, without alternatives, the station pointer cannot be used in a simple manner to solve two angles of *pairs of points which are not common.*

(f) In some cases, a very large scale is required for satisfactory work well away from " points " which otherwise give a strong and sensitive fix. If station pointer plotting were used, the size of sheet and instrument would be not only impractical and cumbrous, but quite ludicrous.

Fortunately, all these difficulties are completely solved by the Sextant Graph, which is based upon that simple property of the circle which implies that, on the same segment, angles at the circumference are equal, and is the principle of the " three point " fix itself. The practical application of this idea is the use of plotted arcs observed simultaneously as co-ordinates of position, and to so select them that they cut as nearly as possible at right angles to each other; also that the angles used are sufficiently sensitive as " subtenses."

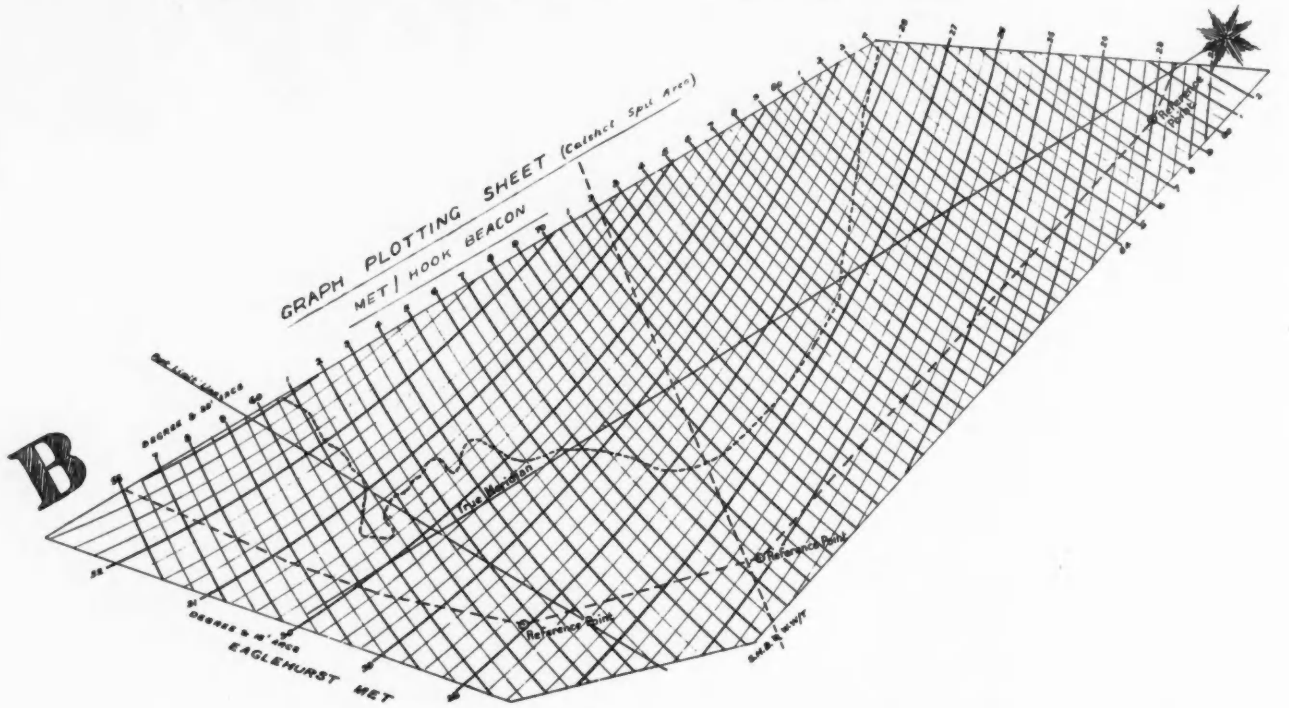
It is not necessary that the fix should be a "three point " one, i.e., where the centre object is common to both sextant observers. Two entirely separate sets of " subtense " objects may be employed, providing angle of " cut " and sensitivity of the " co-ordinates " are satisfactory over the area to be surveyed. The " points" observed need not necessarily be borne upon these full-scale sheets owing to their remoteness.

* Hydrographical Surveyor to Southampton Harbour Board.

Sextant-Graph Plotting—continued

In such cases, however, the work is plotted originally upon tracings placed over " reference points " marked upon standard metal sheets and referred to a system of Rectangular Co-ordinates. These reference points then relate the graph sheets to the Trigonometrical data, and thus a frequent check upon distortion over quite a small area can be maintained.

It will be realised also, that channel edges, transits or other lines drawn upon graph sheets are not affected by general distortion as they are in fixed relation to the arcs



as plotted. The areas affected are upon such large scales that distortion must be very considerable to affect data upon the final " fair " scale. In any case, the " distorted graph " results can be accurately plotted by relating small arc " graticules " to the true graph of the area.

The method of drawing the original arcs of the graphs submitted, was that of simple geometrical construction using beam compasses. The trigonometrical system was related to local Rectangular Spherical Co-ordinates, and thus much simplified. Distances for radii were plotted from standard metal scales giving accuracy to .005"—sufficient for a natural scale of **1/2500**, or even **1/1250**.

The final graph is, therefore, a diagram which enables simultaneous angles to be plotted by inspection in a few seconds after reading *without any intermediate instrument* or process. The graph should have a meridian plotted to permit the Surveyor to make compass courses.

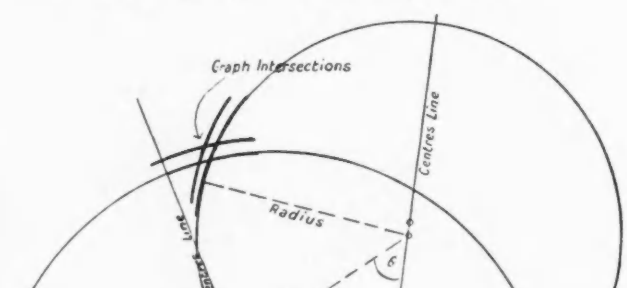


Fig. 1. Example of " Irregular " Three-Point method using " outer point " circle

The advantages are as follows:—

(1) Instantaneous knowledge of position.
(2) Setting and adjusting of Station Pointer eliminated.
(3) Sources of error eliminated, and if vessel is steering on a transit, angles can at once be checked, re-read or repeated, if a fix is seen to be " out of line."
(4) Positions may be located with great ease by steering on one arc until the other angle " comes on." The method is invaluable for " searches."
(5) Intervals between fixes are less, and the Surveyor has greater " command " over all his duties. In conjunction with Echo Sounding the method is ideal.
(6) The method is acknowledged to be the only one, whereby the relatively high speeds possible in Echo work can be maintained with " close-interval " plotting. Drastic changes of depth on the Echo record can be fixed within a few seconds of observing the " tendency."
(7) Quite small " working sheets " can be used on large scales, providing " reference points " are *marked relating the areas to the standard trigonometrical sheets.* If the scale is too large for the use of " beam compasses " the arcs can be determined by calculation, and the use of " railway curves " for *any* scale.

Several further points arising in the paper occur to the writer:—

(1) It is advantageous to plot the arc centres of such graphs upon aluminium sheets, as the problem of distortion does not then arise.
(2) When " points " and arc centres are plotted, it is convenient to directly sweep the arcs on vegetable tracing *paper* superimposed on the metal sheet. Tracing *cloth* in the writer's experience distorts badly, but a good vegetable tracing paper keeps the scale better than any other medium outside metal sheets.
(3) It is suggested in the paper that remote arcs can be plotted by calculating, say, three circumferential points and then accommodating a flexible straight edge to the arc joining them. It will be found very useful to use " railway curves " for this purpose. These can be picked out for the known radius in inches and adjusted even to one point by chord azimuth, which is, of course, at right angles to the bearing of the radius calculated.
(4) (a) It is usually assumed that the three-point " fix " is concerned only with two intersecting arcs, but, of course, there is a third—the arc subtended by the two " outer " points. It frequently happens that a more " open " graph can be plotted by using this included angle, and one of the others with excellent results. Often a normal Three-point Graph produces very strong " fixes," but whilst the arcs are most sensitive, they intersect at very acute angles, especially when the centre object is close.
Figure I illustrates the use of the subtense arc of the two outer points in producing a good " square " intersection close to the centre object.

Sextant-Graph Plotting—continued

(b) The use of "pairs" of points is sometimes very convenient, especially where passing ships may temporarily obscure the "common object" in the Three-point Fix.

The use of separate subtenses means that one observer can take an angle in such circumstances, and this will be useful retrospectively when the next "full" fix in the series is obtained, if steering on a transit.

The principle of plotting is shown in figure II.

(5) The writer has found it best to plot the points accurately on metal, join the subtenses, bisect the chord length and erect the "centre lines"—effecting all this by needle point, which makes a fine bright "score" in such metal, well discernible through tracing paper.

The centres of the arcs are then calculated by the formula:

$$\frac{\text{Chord length}}{2} \times \text{Cot } \theta$$

and plotted by beams from the mid-point of the appropriate chords.

These centres can be checked, say, every 5 or 10 degrees by a check radius from the "points" used calculated by the formula:

$$\text{Radius} = \frac{\text{Chord length}}{2} \times \text{Cosec } \theta$$

This proves the work both as to measurements and perpendicularity of centre line.

(6) The enlargement of Sextant Graphs is an interesting feature if the following points are safeguarded:—

(a) Absolute position cannot be relied upon closely in enlargements.

(b) Relative position of channel contours to arcs would be correct.

(c) If arc "gratitules" were carefully adjusted to "key" arcs plotted upon "parent" metal sheets bearing the enlarged points, the selected plot upon the enlarged graph would be fairly correct, considering the size of sounding figures.

(d) Enlargement of land control is contrary to usual British practice, and for this purpose the writer does not recommend a factor of more than two with the safeguards outlined in (a), (b) and (c).

In conclusion, it should be said that the authors of this paper have probably described the principles of the Three-point Fix in a more lucid and accurate manner than has previously been done, and their principle for determining the condition when arcs cut at 90° is simple and most valuable.

Port Hydrographers would save themselves a very great deal of trouble if they covered areas requiring constant examination with a simple network of such arc "co-ordinates" as have been described. Their criteria of position by simultaneous

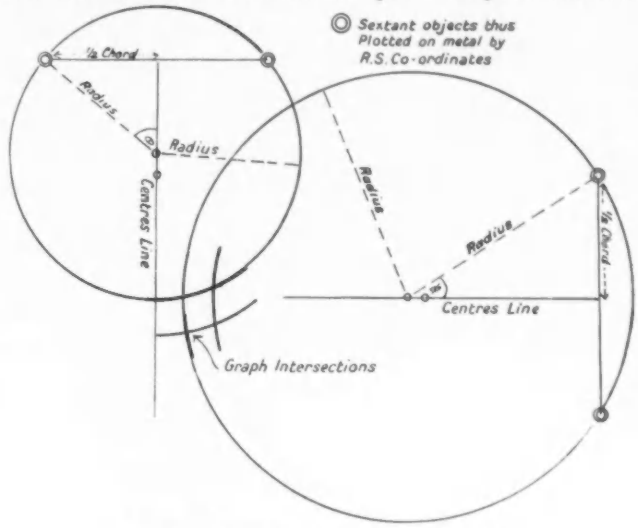


Fig. II. Fix using 2 subtenses—4 points

sextant angles would thus be fixed and the incontrovertible location of points would be simplicity itself; with the aid of Echo Sounding surveys can be tremendously speeded up and thus more frequent. Fine weather periods would thus be more fully exploited.

Above all, the varying value of fixes would be graphically demonstrated to the Surveyor and place his work upon a most secure basis indeed.

But not least of all these advantages is the ability of the Surveyor to take afloat a quite small working sheet which is nevertheless a precise arc plot upon an unusually large scale.

May Graph-plotting methods be more universally known and used.

Erratum.—In the Paper on "Theory, Construction and Use of Sextant Charts" which appeared in the April issue, the following corrections are necessary:

On page 164 in the right-hand column, on line 26, the letters ED should read *BD*. Further down on line 29, the formula contains 2A, which should read simply *A*.

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*Improvements at the Royal Docks, Port of London Authority**

By RALPH ROBSON LIDDELL, M.Inst.C.E.

Discussion

(continued from page 214)

Mr. C. J. S. Anderson observed that the works necessitated by the deepening of the passage between the Albert and Victoria Docks were of particular interest. While the alterations were being made to the railway tunnels under the passage, the London County Council was carrying out a somewhat similar project, but of smaller proportions, in strengthening the main sewer under Victoria Street, Westminster. The old Victoria Street sewer was constructed about 1850, of egg-shaped section, in brickwork, to nominal sizes of 3-ft. 4-in. wide by 5-ft. high, and 4-ft. by 5-ft. 6-in., its soffit being about 13-ft. below street level. Faulty work in the original construction had led to deformation in the sewer, and in 1934 it had been decided that strengthening was necessary. That was effected by cutting out considerable quantities of the old brickwork and erecting cast-iron segments, with 3½-in. flanges and internal dimensions as above, inside the old sewer. Voids outside the rings were packed with broken bricks and grouted. The cast iron was lined with concrete flush with the flanges. About 1,688 lin. ft. of sewer were treated in that manner, the flow of sewage, which was about 18-in. deep in dry weather, being maintained throughout the progress of the works. Materials were taken into the sewer through seven small shafts, but lack of storage space in the street made the works dependent on the daily delivery of stores. That, and interruption by heavy rains retarded progress. The cost of the work was about £9.16 per lin. ft. of sewer.

The use of cast-steel segments at Connaught Road was, as pointed out by the Author, unusual. It would be of interest to know why that costly material had been selected, as it would appear to have little advantage over cast iron except in its greater strength and elasticity. It was realised that the stability of the Connaught Road tunnels, with their direct load of water and thin cover, was of vital importance to the docks and the low-lying neighbourhood, but experience had shown cast-iron tunnels of larger arch-spans to be satisfactory, and cast iron had the advantage of being less susceptible to corrosion than steel. The dimensions of the metal of a 16-ft. diameter cast-iron tunnel for tube railways would be approximately the same as for the 15-ft. 8-in. span tunnels described in the Paper.

It would be instructive if the cost of supplying the steel segments could be given in comparison with the cast iron used in the adjacent pipe-subway. The special cast-iron segments used in lining the Victoria Street sewer cost about £9.13 per ton delivered at site.

The Port Authority was to be congratulated on the great improvement of the Royal Docks carried out under the Author's supervision, but it was felt that the awkward recess retained at the north-western corner of the Victoria Dock might hamper the efficient use of quay-space in that area.

Mr. John Anderson, referring to the different types of quay construction covered by the Paper, observed that those would form an interesting subject of comparative discussion, divided into false quays, solid gravity quays, open quays with ties or bracings, and open quays without bracings.

As shown by the Paper, each of those types had merits peculiar to the particular requirements of site and purpose. The first had been used for providing increased depth of water in front of an existing quay whose foundations were too shallow for deepening alongside. The monolith quay had been adopted on a site where virgin ground of a poor nature had justified the

* Paper read before the Institution of Civil Engineers, November 29th, 1938. Reproduced from the Institution Journal by kind permission of the Council.

Improvements at the Royal Docks, Port of London Authority—continued

sinking of monoliths in the dry, as compared with trench excavation for a mass-concrete construction. The third type of quay made use of existing and new foundations to provide anchorage by tying back, against the horizontal thrust in the usual way. The fourth type, closely akin to the third, differed in that it was self-supporting without any bracing members.

Although the first three types were generally well known, he suggested that the fourth type was unusual, if not entirely novel, and he thought that a few points in connection with the north quay of the Victoria Dock (Fig. 19) might be of interest.

The conditions under which the unbraced type of quay was adopted for that site were themselves somewhat unusual, for the following reasons:—

(1) The construction had to be carried out in open waterway with the minimum of interference to the ordinary dock traffic;

(2) the dock-water at a fixed impounded level limited the construction free-board to about 5-ft. 6-in. from impounded-water level to cope-level;

(3) the quay was required to retain pumped reclamation material subject to consolidation by subsequent pile-driving, without any exterior anchorage.

A block-wall deposited by travelling titan crane and divers might have satisfactorily met all those difficulties, but would have been costly and slower to construct. Other alternatives might have been possible, involving preparatory works, such as tipping banks for operations to be carried out from dry land, but those would have meant earlier sacrifice of existing berthing facilities. In the actual job as carried out, the temporary work seldom preceded the permanent construction by more than about three weeks (about 200-ft. in length of gantry). From those general considerations it was evident that the type chosen met the needs of the situation admirably, having the minimum of under-water work, bracings below impounded-water level eliminated, and the minimum of robust vertical members intended for easy handling by small cranes.

Piled cylinders, having already proved simple and satisfactory, had been incorporated, with a system of rigid-frame construction designed to be carried out entirely above impounded-water level within the limits of structural head-room available, and to provide suitable access, under the whole length of the quay, to mains, etc. There were probably few cases of monolithic portal construction which were called upon to meet permanent side-sway thrusts of such magnitude as were imposed upon that quay, in addition to the quite heavy intermittent vertical loadings from cranes and railway rolling stock.

Compared with the solid type of quay-wall, it might be pointed out that the horizontal pressure transmitted to the rigid frames, spaced at 24-ft. centres, was only a proportion of the total thrust, consisting of the top reaction from the sheet-piling and the pressure on the rear cylinders. The balance was taken up by the passive resistance in front of the sheeting, whose relative flexibility ensured independent action between cylinders and the maximum relief to the top thrust. The horizontal reaction of the frames was provided at the foot by the passive resistance of the ground in front of the cylinders, and the piles driven some 12 or 13-ft. below the cylinders. Partial fixity was assumed at the foot of the cylinders in considering the frame-strength.

In connection with the analysis of the statically-indeterminate frame-stresses, it would be impractical, if not impossible, to provide the ideal theoretical conditions of section and profile from cylinder to frame-beam to justify highly mathematical treatment. The many assumptions for the application of theoretical analysis by methods of slope-deflection, or of least work, etc., being seldom realisable in practice, the results were apt to be of purely academic interest, and in the present case the more direct and quite sufficiently accurate Hardy Cross methods of moment-distribution was used. That method had the advantage that by successive approximation, numerical values of bending moment could be quickly computed, based on trial assumptions of relative stiffness of members, with a view to finding the best combination for construction-depth, section of frame-beam, and simple arrangement of steel, etc., to satisfy the varying load conditions.

Since the loading conditions would only operate together intermittently, the vertical load moments increasing or reducing the value of the horizontal thrust moments as the case might be, the permanent and intermittent conditions were considered separately, and the worst combinations were readily found by collecting bending moments according to their positive or negative sign. Under the maximum conditions of horizontal thrust the deflection of the quay observable was approximately ¼-in., which could be entirely attributed to the elastic deformation of the frame-members, which would be expected.

In view of the uncertain quality of the ballast concrete deposited in the cylinders by hopper skip through water, and the effectiveness of the steel bond, the design stresses in the steel and concrete were naturally kept somewhat lower than for work above water. Actually, there was no evidence of hearting concrete being defective. The ballast was carefully tested for sand-content, and the quantity of cement was adjusted as necessary to secure uniformity of the quality of the mortar.

Referring to the method of construction of the deck, involving suspension from heavy steel girders during concreting (the transverse beam ribs already having been concreted), it might be pointed out that the ribs were designed to act with the slab as T-beams. To make the ribs themselves (with approximately only half the depth of the T-beams) sufficiently strong to act as rectangular beams for supporting the dead load of wet concrete, would have involved approximately 20% extra steel.

The extra cost of stiffening the quay section against horizontal thrust was actually less than the estimated cost of providing satisfactory exterior anchorages.

In dock engineering in Great Britain, mass had previously been the criterion of deep-quay design, often with resultant prejudice to cost. On the other hand, the design of lighter wharves and jetties in reinforced concrete had tended to follow the lines of similar structures built of timber, transverse strength being provided by diagonal bracing or raking piles, which, if exposed, were prone to slight accidents, causing local fracture with spawling and baring of steel, and necessitating consequent maintenance expenditure.

Those limitations had been successfully avoided in the work under discussion by the co-ordination of modern design-technique and construction methods which were undeveloped 25 years ago, and it might perhaps be agreed that the best features of mass, economy of design, and probable low maintenance costs had been retained in the type chosen for the north quay of the Victoria Dock.

Mr. R. F. Hindmarsh observed that the Author stated that the lock and passage-way leading to the Royal Albert Dock had been reduced in depth by inverts rising 4-ft. 6-in. to the side walls. The main entrance to Northumberland Dock on the Tyne had similar inverts at both ends of the entrance basin, and a few years ago those were cut down so as to make a level bottom right up to the side walls, to suit modern square-built ships. The whole of the entrance floor and walls were built on piles, so that the invert was not acting as an arch and could be safely removed. The method of doing the work was very similar to that described by the Author for deepening the passage-way between the Royal Albert and Royal Victoria Docks. A line of bore-holes was put down with hand jumpers close to the foot of the side walls, and formed into a trench by divers, in order to enable the diving bell to be placed horizontally over the work; the bell was slung from a lifting keel and was equipped with the necessary air-pumps, telephone, and electric light. The size of the bell was 9-ft. by 7-ft., and it weighed 12½ tons; four men could work comfortably in it. Compressed-air tools were used, but were not so effective as was anticipated, the material being sandstone. A mason used to that material could do as well, or better, with his hand tools than the man with the pneumatic rock-drill, which was rather surprising. The whole area was finally roughly dressed-off by the mason.

The Author was fortunate in being able to narrow the Royal Albert Dock, and so to avoid expensive underpinning of the quay walls. Why were only two piles driven in the columns, and how far did they get into the ground? What maximum weight did the columns carry, allowing for the cylinder sunk to a good hard foundation to take part of the load? Were the piles timber or reinforced concrete? Mr. Hindmarsh was particularly interested in that work as he had just designed an 800-ft. quay for Tyne Dock, where, owing to the ground for a considerable depth being little better than silt, six and eight piles driven down to hard ground were to be used to carry the weight, no bearing value for the bottom of the cylinder itself being taken into account. The cylinders were constructed by means of steel sections up to ground-level, 10-ft. 6-in. in diameter, and carried 6-ft. diameter reinforced-concrete columns from ground-level to deck-level. Removable steel sections of cylinder were first carried up to above high water, and after pile-driving was finished the bottom was sealed, the cylinder pumped out and filled with concrete, and the column built in the dry. The removable steel sections were then unbolted and used over again. A substantial timber fendering was provided in front. There did not, however, appear to be any fendering at the north quay widening of the Royal Albert Dock.

Could the Author say whether the forty-three 3-ton cranes of 60 to 65-ft. radius provided in 1916 on the north quay of the Albert Dock, to replace the old hydraulic cranes, had been found sufficient in outreach to meet requirements? The outreach beyond the face of the quay would be about from 48 to 53-ft.

Mr. Cecil Peel observed that the scheme for the remodelling of the north side of the Royal Victoria Dock was at present in hand, the construction of the warehouses having been commenced and the foundations of the one at the eastern end com-

Improvements at the Royal Docks, Port of London Authority—continued

pleted. Those foundations had involved the driving of three hundred and thirty-four 16-in., and one hundred and twenty-six 14-in. sq. reinforced-concrete piles, 50-ft. long, through the reclaimed ground into the virgin ballast beneath. As stated by the Author, the reclamation filling consisted of ballast dredged from the dock, and partly dumped and partly pumped over the site of the warehouse to a total depth of some 30-ft. The dumping was completed in April, 1937, and the pumping, which took three weeks, in May, 1938. Some observations upon the settlement of that filling might be of interest. Prior to piling, the settlement averaged about 1-in. Pile-driving, which occupied 11 weeks, was completed in October, and during that operation further settlement took place of an interesting nature. There was an average settlement over the site of about 1-ft., but in the immediate region of the groups of three or four piles (the groups being 24-ft. by 25-ft. apart) the settlement was greater, reaching a maximum of 3-ft. and averaging 20-ins. In between the pile-groups it was about 6-ins. The driving was done by a 4-ton semi-automatic steam hammer, falling about 2-ft., and finally 3 ft. in order to obtain the required set, which caused considerable vibration and shaking of the ground. Indeed, in places fine ballast was fed around the piles to fill up the depressions in the ground, and the vibration caused it to shake down into the interstices of the ballast and to disappear. Since the completion of the piling no further settlement had been recorded.

The total displacement of the piles in the filling amounted to about 850 cu. yds., or about 1% of the volume of the filling on the site of the warehouse, and the settlement to about 4%, or a total diminution in volume of 5%. It was very satisfactory to note, therefore, that in spite of that consolidation and vibration of the ground, which was bound to have increased the lateral pressure, no movement whatever of the new cylinder-quay had been observed, and that provided a valuable check upon the stability of that type of construction. Instances had been known where quay-walls, particularly of the solid type, had been pushed forward and fractured as a result of the driving of large numbers of piles at the back of them, especially when the ground was very firm.

The demolition of the southern ends of the solid jetties in the Royal Victoria Dock involved careful procedure, owing to the light construction of their outer walls, and also to ensure that the debris could be satisfactorily removed by dredger. Moreover, owing to the close proximity of buildings and traffic, blasting had to be restricted. The operations involved were mentioned by the Author, and the following was a record of the drilling and blasting. The vault-arches were founded upon continuous concrete walls about 4-ft. thick, carried down from vault-floor level at + 6.00 N.D. to the ballast at about −2.50 N.D. to −8.00 N.D. The brick outer-vault walls and their concrete foundation walls, founded on ballast at about −4.00 N.D. to −8.00 N.D., were drilled from arch-springing level at + 14.00 N.D., and the inner foundation walls from vault-floor level, by 4-in. and then 2-in. cruciform drills driven by compressed-air tools working at a pressure of 80 lb. per sq. in. The holes were spaced about 4-ft. 8-in. apart in the centre of the walls, which were drilled nearly to the bottom. The holes were cleared by a jet of compressed air which ejected water and débris from them.

The charges were made up with 4-oz. cartridges of Polar Ammon gelignite, with L.T. No. 6 electric detonators wired on to laths and lowered into the holes, the tops of which were tamped with soil. The detonators were separately tested in a cast-iron pipe before use, using a galvanometer and battery. The charges were wired in series and connected to a Schaffler exploder, which was operated by the insertion of a key which, on rapid rotation through 180 degrees, generated an electric current, contact with the firing circuit being made at the end of the stroke when the current was a maximum. The exploder was tested for firing twenty-five detonators in series. Before firing, the complete circuit was tested by galvanometer. No trouble through misfiring had been experienced.

The charges were made up approximately as shown in Table I.

TABLE 1

Depth of hole: feet	inches	Charge about 4 feet from top: lb.	Charge near middle lb.	Charge about 2 feet from bottom: lb.
8	6	—	$\frac{3}{4}$	$2\frac{1}{4}$
10	0	$\frac{1}{4}$	1	$2\frac{1}{4}$
12	0	$\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{1}{2}$
14	0	$\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{1}{2}$
18	0	$\frac{1}{2}$	2	$2\frac{1}{2}$
20	0	$\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
22	0	$\frac{1}{2}$	2 and 2	$2\frac{1}{2}$

The holes were fired singly, but four holes were charged ahead of the one fired to avoid trouble in charging.

The outer jetty walls, consisting of 14-in. brick arches with 3-ft. of concrete backing, were demolished in the following way. Divers prized holes in the brickwork and placed charges close to the cast-iron T-piles or at the back of the brickwork. The placing and firing varied at the divers' discretion to suit the way in which the arches collapsed, but generally four 3-lb. charges were used per 7-ft. bay of brickwork, the top one 1-ft. below water-level and the others 7-ft. apart. The two top charges were connected and fired together, and the bottom two similarly connected. The inner-vault foundation walls were blasted first, in the dry, followed by the outer-vault walls and the jetty walls, in the wet. The jetty walls were demolished about 20-ft. ahead of the outer-vault walls for the safety of the divers, as the two walls were tied together by tie-rods. All large pieces of jetty wall which collapsed on to the dock bottom were re-blasted.

The stability of the jetty walls during demolition was remarkable in spite of their very light construction.

The Paper provided a valuable comparison of the two types of dock construction—jetties and a long straight quay—and the latter appeared to have greater merits than the former. With the jetty type of dock more land and water space was required than with the straight quay, for a wide main dock had to be provided to allow ships to be manœuvred into their berths at the jetties, besides the space required for the jetties and intermediate "docks." Moreover, considerable economy might be realised in the straight-quay type, both in regard to main and subsidiary works. In addition to the quay walls, roads, railways, and mains had all to be provided, and with jetties not only had those to be provided along the jetties themselves, but also along the land at the back to connect the jetties. With the long straight type of quay that additional service was obviated, and one road and one set of railways and mains at the back of the line of sheds generally sufficed. The whole lengths of quay, roads, etc., had full use, and there were no comparatively idle sections at the ends of jetties and the heads of "docks." The accounts of the respective works at the Royal Albert and Royal Victoria Docks showed that it was a much easier, quicker, and cheaper matter to modernise the straight type of dock than the jetty type.

Mr. J. H. W. Turner pointed out that, in the section of the Paper dealing with the deepening of Connaught Road passage, it was made clear that the diving bell was of greater value than the divers. From the contractors' viewpoint, however, he would like to emphasise the advantage of the diving bell in facilitating frequent and easy inspection of the work being done. Whilst he could strongly recommend it as the best means of tackling any similar problems, he would, however, point out that it lost its usefulness where the working surface was other than approximately level. Before starting work with the bell he had been rather apprehensive about the intensity of the noise which would be caused by using two pneumatic concrete-breakers inside a small metal chamber, but it might be of interest to know that no discomfort had been experienced. The supply of compressed air for the pneumatic tools was at a pressure of 100 lb. per sq. in., but since the pressure of 12 lb. per sq. in. in the bell was also drawn from the same pipe-line, an air-filter was introduced into the pipe-line in order to make the air suitable for breathing. In the pipe-subway the demand for compressed air never exceeded 1,000 cu. ft. of free air per minute. The incidence of compressed-air illness was very small, and it was of interest to note that its occurrence agreed with recent research; namely, that no cases developed until the pressure reached 17 lb. per sq. in.

It would be noticed that all flanges on the cast-iron lining had machined faces. In recent years that had become common practice in sub-aqueous tunnels. Where the tunnel was hand-driven it was undoubtedly an improvement, provided that strict supervision was maintained. Where the tunnel was shield-driven, however, he had come to the conclusion, from personal observations, that the extra cost of machining the circumferential flanges was to a substantial extent lost. That was particularly the case where the shield had a moderate diameter. A shield would show a persistent tendency to wander from its true line and level. Where the deviation was small, correction might be made by applying unequal ram-pressures at suitable points around the leading circumferential flange, but in doing that, there was a tendency to distort the shape of the cast-iron lining. Where the deviation was more serious, some form of packing had to be introduced between adjacent circumferential flanges immediately behind the shield. Moreover, even if ideal conditions could be obtained for the erection of a length of cast-iron lining, it would be found that the tolerances allowed to the segment manufacturers precluded any chance of building the perfect tunnel. Slight variations in the width of different segments would cause unavoidable separations of circumferential flanges. Since, however, ideal conditions for the sub-aqueous tunnel-lining erection should not be anticipated, he was not in favour of incurring further expense by imposing finer tolerance on the manufacturers.

(Concluded on page 240)

*Construction of a New Quay at the Lock Entrance Albert Edward Dock, North Shields**

By R. B. PORTER, B.Sc., Assoc. M. Inst. C.E.

Fig. 1. General View of the environment of Albert Edward Lock Entrance, showing new Quay Shed in centre of background

General Description

THE quay, which has been named "Tyne Commission Quay Extension," forming the subject of this paper, was constructed in 1936-37 by the Tyne Improvement Commission, principally for Norwegian cargo and tourist traffic between the Tyne and Oslo. It is situated on the North bank of the Tyne, about two miles from the mouth of the river, and is in line with and just outside the lock entrance to the Commissioners' Albert Edward Dock. (See plan).

The berth is 450-ft. long, and has a depth alongside of 22-ft. at L.W.O.S.T., this being limited by the foundations of the lock entrance wall which forms the major portion of the quay. The triangular area between the entrance wall and the Tyne Commission Quay is of reinforced concrete construction. There is a single-storey transit shed 250-ft. long by 80-ft. wide, formed of two 40-ft. bays with external loading platforms at three sides. Between the shed and the face of the quay are two lines of railway and a crane track. The shed is completely surrounded with concrete paving, laid flush with the railways, and is connected by a short length of road to the existing paving at the South end of the Tyne Commission Quay. The quay is equipped with electric semi-portal travelling cranes, two of $1\frac{1}{2}$-tons and one of 10-tons capacity; two electric capstans with fairleads, and water service for ships. On the North side of the approach road new Customs and shipping offices have been erected, together with timber lock-up garages for passengers' cars. (See Figs. 1 and 2).

In 1938, the transit shed was extended eastwards by approximately 50-ft. to meet the main-line railways behind the Tyne Commission Quay shed, and in order to facilitate the movement of passengers and goods, a steel drawbridge, described later, was constructed to cross the main lines between the two sheds. The drawbridge is covered by a fixed canopy having sufficient clearance for rail traffic below it. When not in use, it is housed in a recess formed under the floor of the new shed.

At the north-east corner a turntable, also described later, was built into the reinforced concrete decking to enable wagons to be run direct off the new quay on to the main lines. A further addition was the provision of a fourth electric crane, having a lifting capacity of three tons and a maximum radius of 80-ft.

* Paper read before the Newcastle and District Association of the Institution of Civil Engineers on February 7th, 1939.

Clearance Work

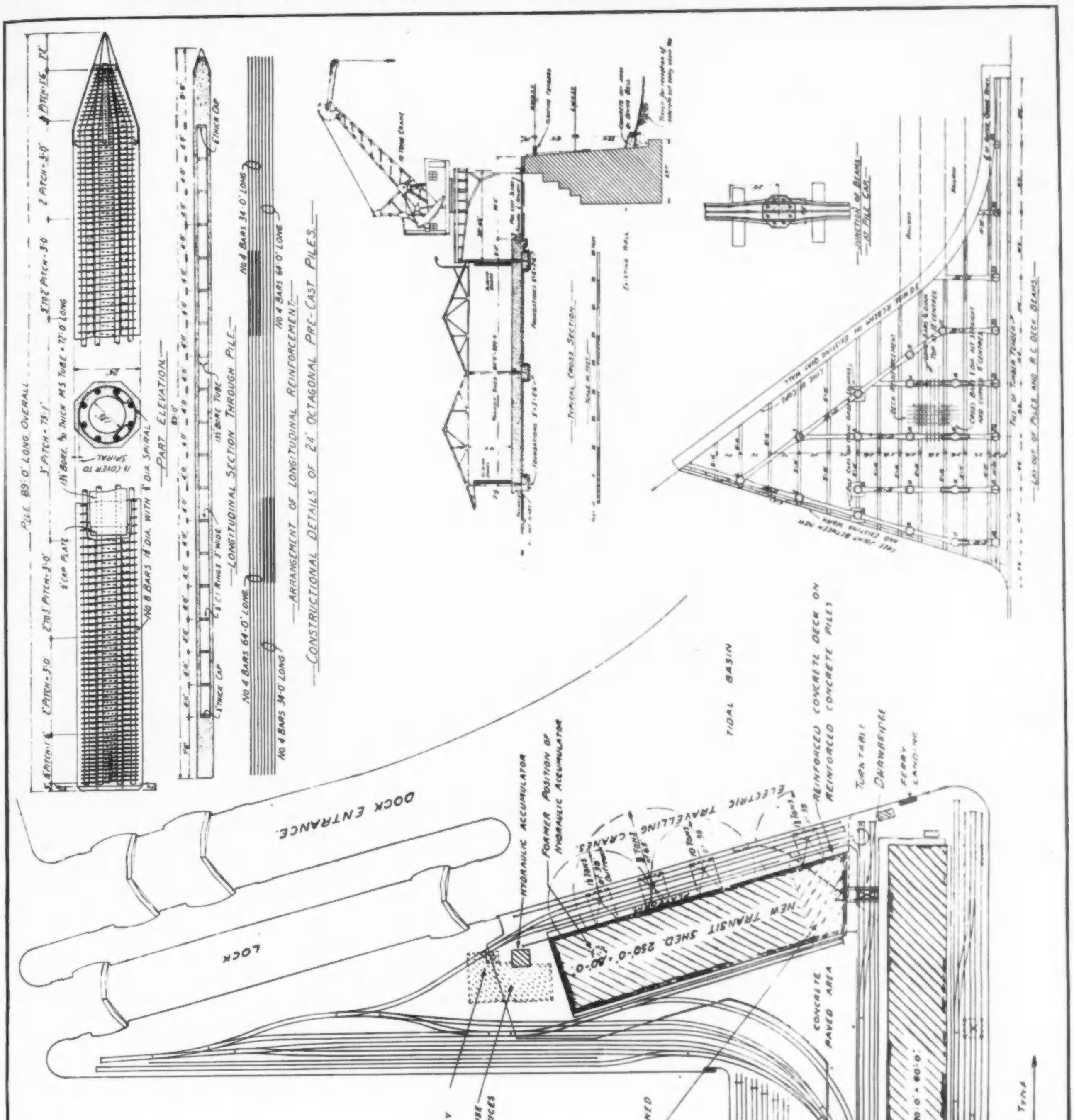
Work on the construction of the quay was commenced early in November, 1936, by the demolition of the old hydraulic pumping station, a stone building divided into four welled compartments for engines and boilers, and having a brick chimney 120-ft. high. This station, which was completed with the Albert Edward Dock in 1884, supplied hydraulic power for the cranes, gate machines, and coal hoists on the river front until 1927, when it was closed down following completion of a new electrically-operated station on the South side of the dock. Owing to the proximity of the dock walls, hydraulic accumulators, lock gates and cranes, etc., the demolition of the chimney by the usual method of felling, was considered too risky, and it was, therefore, decided to take it down bit by bit from scaffolding erected at the top. Blocks of brickwork, about 2 cu. ft. in size, were loosened and dropped through the centre of the chimney, the debris being removed from time to time through a hole cut in the side of the chimney base and afterwards used for filling up the wells in the engine and boiler house.

The accumulator tower, forming part of the old buildings, was retained, together with the accumulator within it. This necessitated re-facing the southern wall of the tower with rock-faced freestone, suitably sized stones from the demolition work being set aside for the purpose. The hydraulic accumulator shown on plan near the East side of the engine house had to be removed and re-erected on another site as it was in the way of the new shed. The accumulator casing was dismantled in sections and the slag ballast inside it shovelled out by hand and wheeled to railway wagons. The ram and cylinder, weighing together over 16 tons, were lifted by floating crane after unsuccessful attempts at freeing them from the base casting by means of tackle attached to the top of the guide tower structure. The concrete foundation block was left in.

Reinforced Concrete Quay Work

As already mentioned, the works over the water space between the Tyne Commission Quay and the skew portion of the river wall are of reinforced concrete construction throughout. Test piles, driven during the early stages of the construction of the Tyne Commission Quay, made it obvious that piles driven to at least 75 to 80-ft. below L.W.O.S.T. would be required at the North end, and steel piles of cruciform section, varying in

Construction of New Quay, Albert Edward Dock, North Shields—continued



Construction of New Quay, Albert Edward Dock, North Shields—continued

length from 75 to 85-ft., were driven in a steel cylinder, which was afterwards filled with concrete.

In the case of the present quay, it was decided to adopt 24-in. hollow octagonal reinforced concrete piles, 90-ft. long. Actually, owing to the longitudinal reinforcing bars being supplied 1-ft. shorter than ordered, the piles were moulded to a length of 89-ft. Their design and construction are shown on the plan and in Fig. 3.

The piles were moulded on a site immediately westward of the site of the reinforced concrete quay at about 4-ft. centres.

point. After inserting timber runners under these collars, it was possible to roll the pile over easily by parbuckling.

Pile Driving

Timber staging piles varying in length from 70-ft. in the front row to 50-ft. in the back row, were driven in rows parallel to the quay face, two temporary piles being placed between each pair of permanent piles. At deck level, and slightly above L.W.O.S.T., timbers were fixed between the staging piles to form guides for driving the concrete piles.

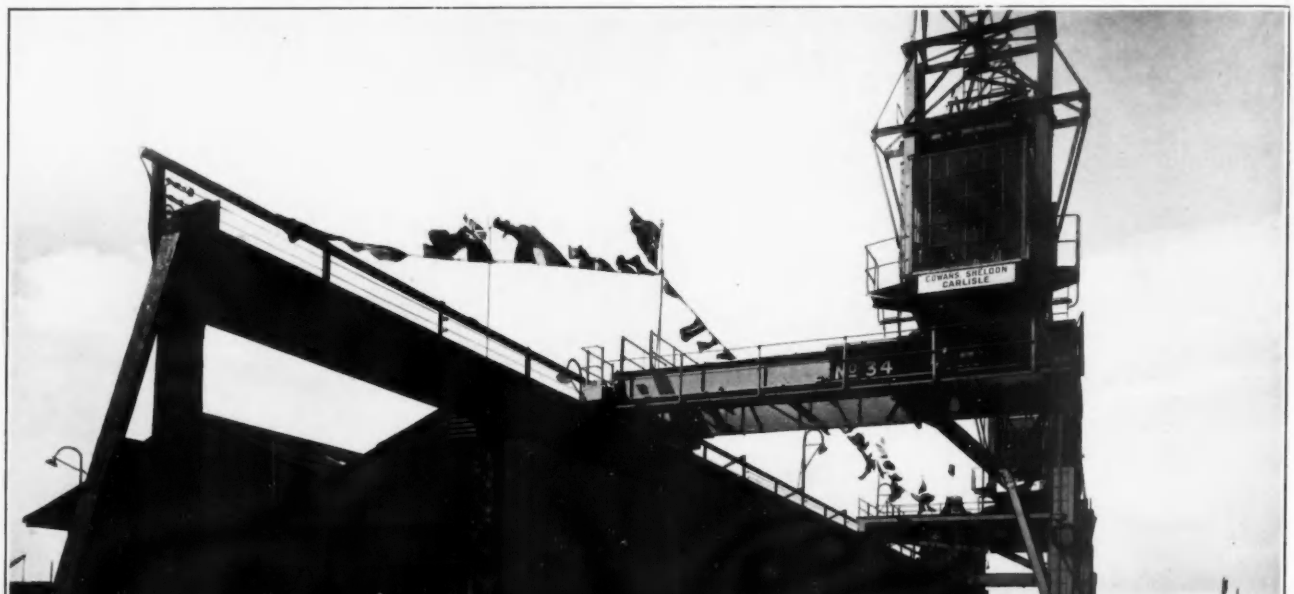


Fig. 2. View of New Quay and Shed

Timbers were laid at right angles to the axis of the piles and carefully levelled and packed. Longitudinal timbers, $2\frac{1}{2}$-in. thick, to form the bottom side of the piles, were next laid and the moulds constructed over them. The steel reinforcement skeletons were assembled on trestles westward of the pile beds; on completion they were lowered to the ground and rolled into position in the moulds. Concreting of the first two piles was commenced on the 23rd December, 1936. The concrete was wheeled in barrows from the mixer and tipped from staging fixed at the level of the tops of the moulds. During pouring operations the moulds were vibrated on the outside by means of two light pneumatic hammers. This, while apparently effective in bringing the air bubbles to the surface, did not prevent such defects as honeycombing and small hollow patches which were afterwards discovered on the underside of some of the piles. Internal vibration might have produced better results but, of course, the presence of the core tube prevented this.

Six sets of shuttering were made to enable three piles to be concreted daily, although this was actually possible on only two days. The average number concreted daily worked out at two.

It was hoped that the concreting of the 23 piles would be completed by the 8th January, 1937, but delay in delivery of some of the steel reinforcement deferred completion until the 14th January. The moulds were stripped three days after concreting.

Turning of Piles for Inspection

For the purpose of making a thorough examination of the underside of the piles before driving, each one was rolled over about half a turn. At each slinging point a short length of flat bottom rail was inserted under the bottom shutter at right angles to the pile axis and with the flange uppermost. Jacks were placed at the ends of the rails and, after the pile had been raised a few inches, timber segments surmounted by a steel band, were fitted to form a collar, 4-in. wide, near each slinging

Owing to their great weight (17 tons) and length (89-ft.), the slinging of the piles presented a special problem. It was realised at the outset that they could not be handled by the land plant available, the Contractors' largest crane having a capacity of 10 tons. The 150-ton "Titan II" crane was, therefore, employed. (See Fig. 4). The operation was carried out without incident and occupied only four days.

For the driving, which was commenced as soon as the first pile (No. 6) had been pitched, a steel piling frame, 77-ft. high, was employed. This was delivered to the site in two sections, which were bolted together on the ground and then raised complete into the working position by means of rope tackle. The frame, with its boiler and steam winch, was mounted on a timber platform which travelled on long hollow steel rollers operated by rope tackle from the winch. To protect the piles during driving, cushions were used, made up as follows:—

One fibre door mat next the pile head; one pad, consisting of layers of old hessian and paper cement bags, built up to 3-in. thick by 2-ft. 6-in. square, and having its edges bound with 16-gauge wire, and one steel plate about $\frac{3}{8}$-in. thick on top to receive the hammer piston rod. This form of protection proved very successful, the heads commencing to crumble only after the required set had been obtained. It was, of course, necessary to renew the cushions fairly frequently, but this slight expense was more than justified.

The set required in the case of the piles subject to the greatest loading was 12-in. for 250 blows from a 4-ton hammer falling 3-ft.

A single direct acting steam hammer, having a 4-ft. 6-in. stroke and cylinder weight of four tons, was used, but the actual stroke seldom exceeded 3-ft. The following is a typical case of the number of blows given for the last few feet of driving:—

140	164	179	196	244	321

The minimum period allowed between the completion of the

Construction of New Quay, Albert Edward Dock, North Shields—continued

Fig. 3. Reinforced Concrete Quay Substructure

moulding and driving of a pile was 23 days, the average being about 30 days.

The design required the piles to be driven to finish at approx. 8-ft. above L.W.O.S.T. (L.W.O.S.T. is 20-ft. below deck level) with 18-in. square continuation columns constructed *in situ* up to the underside of the deck. Actually, the majority finished many feet above deck level. To avoid the waste of cutting the piles at the designed level, i.e., 8-ft. above L.W.O.S.T., it was decided to cut them just below deck level and modify the bracing design to suit. In the original design all piles were connected by a system of low-level horizontal precast bracings, with diagonal members between the first and second rows. The modified bracing system was based on the view that the piles, being continuous right up to deck level, require little or no intermediate bracing, and that the triangular frames between the first two rows will transfer any horizontal thrust directly through the deck beams to the wall behind.

The horizontal and vertical triangular frames and the eyed "dumb-bell" bracings were each precast in a unit and threaded over the piles by crane. The eyes were made considerably larger than the cross section of the pile in order to facilitate this operation, and were left rough so as to bond well with the piles which were bared at the appropriate levels. The sloping legs

Fig. 4. Pitching of Piles

of the vertical triangular frames were furnished with temporary timber struts as a safeguard against damage when lowering into position. (See Fig. 5). The three horizontal bracings at the West side were concreted into dovetailed holes cut in the river wall.

The piles were cut off a few inches below deck level and stripped to the underside of the bracing connection blocks and deck beams. This involved breaking into the hollow cores of those piles which could not be driven as far as deck level but, as it had previously been decided to fill all the cores with concrete, the question of plugging for the pouring of the bracing connections did not arise. The cores were filled through a long 4-in. diameter tremie pipe built of flanged sections, which were removed singly as the cores were filled.

After driving, the piles were very carefully examined both above and below L.W.O.S.T., and any defects were satisfactorily repaired by means of steel cylinders, 2-ft. 6-in. in diameter, formed in two semi-circular sections so that they could be easily bolted together under water by a diver. The lengths were varied according to the height of the defects above the mud level, the maximum length being 12-ft. After bolting, they were pushed down about 2-ft. into the mud by weights added to the top and afterwards filled solid to the top with neat cement grout. Above L.W.O.S.T. the defects were filled with cement mortar applied from staging.

The decking is 11-in. thick, and was formed in two layers, the 5-in. thickness of the bottom layer being determined by the level of the underside of the railway rails, which were fixed before placing the top layer. The work was carried out, as far as possible, in alternate bays of width equal to the beam spans, commencing always in the centre of a span.

The granite coping and top course of the adjoining portion of the river wall were removed by undercutting with steel wedges and by firing shots placed in the bed joints. A reinforced concrete wall beam, 3-ft. wide and varying in depth from 2-ft. to 4-ft., was substituted. This was bonded to the masonry below by means of 1½-in. diameter steel dowels staggered at 3-ft. centres. The deck-beam reinforcement was extended to intersect the wall-beam reinforcement, the concreting being carried out in one operation.

There is no structural connection between the new and existing quay at the East side, a ¼-in. space being left by inserting ¼-in. softwood packing when concreting the bottom and top layers of decking. After concreting the top layer, the packing was removed and the space run in with bituminous filling to form a flexible joint. A similar expansion joint was formed in the top layer of decking over the centre of the wall beam. The whole of the concrete work from low-water level up to and including the underside of the deck was given two coats of bituminous solution.

The quay is fendered with creosoted pitch pine horizontal and vertical timbers, which were fixed vertically at the East end and packed out to correspond with the batter of the river wall at the West end. The horizontal timbers are secured by bolts through holes left in the horizontal concrete bracings. The vertical timbers are not directly attached to the front piles, but are bolted through steel angle cleats to the ends of the horizontal timbers which abut them. Additional support is given to the verticals by steel straps fastened around the piles just above L.W.O.S.T.

Loading

The quay was designed for the following loads:—

Deck slabs—3-cwt. per sq. ft.

Deck beams—Axle loads of 13, 16 and 13 tons. Centres of axles 7-ft. and 5-ft. 8-in. respectively; 25% allowance for impact.

Piles under elevated crane track columns—73 tons, including the weight of the pile.

Front crane track beam—Single wheel load of 35 tons, plus 25% for impact.

Transit Shed

The steel transit shed is adapted for fish and general storage. The first stage in its construction was the excavation and concreting of the column foundations, which are 6-ft. sq. under the front crane columns and 5-ft. sq. under the centre and rear columns, the depth of foundation varying from 2-ft. to 3-ft. below average ground level, according to the nature of the soil.

After erection of the main steelwork members and 15-in. platform and side walls, the floor space was filled in with 10 : 1 concrete. This filling is from 2-ft. to 3-ft. thick, according to

Construction of New Quay, Albert Edward Dock, North Shields—continued

the surface of the ground underneath. The river ballast used was unscreened and contained small boulders and stones of all sizes. It was brought alongside the quay in barges containing 70 to 100 tons and unloaded by crane straight into the mixer. After mixing, the concrete was fed into jubilee wagons and

Fig. 5. Precast Concrete Frames

deposited between shuttering in alternate 12-ft. 6-in. bays extending across the full width of the floor. The bays were keyed together by a continuous "birdsmouth" projection formed along one side. The concrete set surprisingly hard, and while still green was surfaced with 4-in. of whinstone concrete laid to a cross-fall of 4-in. towards the central drainage channel.

The flooring for the extension of the shed in 1938 was done in similar fashion, except the part which comes over the ferro-concrete quay work, which is of reinforced concrete 8-in. thick, supported by concrete sleeper walls, 36-in. high by 9-in. thick and 7-ft. 3-in. apart, built over the existing main deck beams. The walls were designed as continuous beams, and contained on the average about 18-lbs. of steel per ft. run. The timber shuttering for the deck slab was withdrawn after dismantling through a hole formed in one of the side walls of the drawbridge recess.

The surface of the front and back platforms is protected against wear by steel composition slabs $1\frac{3}{16}$-in. thick bedded in 3 : 1 cement mortar on the rough bottom concrete and laid to a cross-fall of 1-in. in 10-ft. The exposed edges are protected with $2\frac{1}{2}$-in. by $2\frac{1}{2}$-in. by $0\frac{1}{2}$-in. angles secured by rag bolts to the platform walls. Along each side and at the end doors continuous cast-iron drainage channels with connections to gulleys are provided to drain off any water that might penetrate under the door ploughs in wet and windy weather. All drainage channels within the shed are covered with diamond pattern welded steel gratings. Flights of steps were formed in the platform walls at three corners and near the centre of the front platform, while access for barrows is facilitated by ramps at the East gable and South-west corner. The ramps are edged with T bars fixed with one flange projecting upwards to prevent barrows running over the side, and are surfaced in the same manner as the shed floor.

The shed is fitted on all sides with sliding doors. The columns, including those supporting the crane girders, are spaced at 25-ft. centres and the roof truss at 12-ft. 6-in. centres. The elevated crane track girders are of plate web construction, and the valley and back eaves girders are 20-ft. by $6\frac{1}{2}$-ft. R.S.J.S. At the East gable there is a clear opening of 36-ft., a lattice portal girder being used to carry the doors and the two lattice girders supporting the roof over the drawbridge between the two sheds. The roof and side sheeting is asbestos protected corrugated 22-gauge steel, fixed by the makers' men; each roof-fall is glazed with a single line of wire-woven glass.

(To be continued).

Improvements at the Royal Docks, P.L.A.

(Concluded from page 235)

In the pipe-subway a large proportion of the bolts were of a special nature to carry the hangers for the various cables and service-pipes. It sometimes happened that a contractor for a sub-aqueous tunnel was instructed to instal similar fixings after the completion of caulking. He would like to point out that in doing so, the water-tightness of the tunnel was liable to be seriously damaged, and that remedial measures might be both tedious and costly.

The Author, in reply, observed that there seemed to be some confusion over the method of supporting the beams and decking of the north quay of the Royal Victoria Dock (Fig. 19) during construction. The pre-cast beams (Fig. 10) were used as forms for the coping beams and smaller ones for the centre longitudinal beams. Timber forms were used for casting *in situ* the transverse beams up to the underside of the deck-slabs; there was no difficulty in erecting or withdrawing those supports as they were well above dock-water level. Rebates were formed in the centre and transverse beams on which to land 4-in. thick pre-cast slabs used as forms for the 12-in. decking. During the placing and hardening of the concrete of the 12-in. decking, each transverse beam was suspended from a steel truss 5-ft. 6-in. deep by means of four bolts, two to each span of the beam, hooked on to similarly placed staple-bars embedded in the rib of the beam. The strain was taken by turning the bolt-nuts until the centre pair gave a part turn with an 18-in. spanner-leverage. By observation no uplift took place in the ribs, and a deflection of about $\frac{1}{8}$-in. was recorded after depositing the wet concrete. The soffits of all transverse beams were inspected after stripping, and no fractures or other defects were observed. After the deck-slabs were placed in position access to the underside was obtained by the manholes mentioned on page 172.

No wooden fendering was provided on any of the quays described, but the face of the coping-beams was formed of 12-in. of $1\frac{1}{2}$-in. broken granite concrete of 1:2:4 quality, to resist abrasion by barges. The removal of "I" jetty had greatly improved the access of vessels to "Z" berth.

The cost of construction of the typical three-cylinder quay shown in Fig. 19, including crane and rail tracks, but excluding demolition of jetties and forming ballast bank, was about £55 per ft. run.

The cylinders in the Albert Dock quay were of the standard type shown in Fig. 20; they were sunk 2-ft. below dredging level, and contained two concrete piles, as the loading was not so great as on the Victoria Dock north quay, where three piles at 50 tons were required in addition to the base of the cylinder at 4 tons per sq. ft. on the virgin ballast. The deepening of the Albert Dock was carried out across the dock to 50-ft. off the south quay; the same limit applied to the quay north of the passage.

The outreach of the electric cranes on the north quay, referred to by Mr. Hindmarsh, was up to 53-ft. 9-in., as the front crane-rail was 4-ft. 6-in. back from the quay-face to clear the stem of barges. That outreach was sufficient to meet requirements, except where vessels of large beam were "dummied" off about 23-ft. to enable barges to be loaded between vessel and quay. For that purpose an 18-ft. crane-track was at present being laid down on a portion of the north quay of the King George V Dock to take 3-ton electric cranes of 80-ft. radius.

Referring to the strengthening of the twin railway tunnels, the cost of the cast-steel segments ready for erection was £25 per ton, as compared with £9 per ton for the cast-iron segments of the subway and shafts, but the greater strength and elasticity of the steel justified its use in the exceptional situation described. The segments were machined by twin millers of American construction.

The pre-cast reinforced-concrete foundations described by Mr. Deane for the roller-paths of the Victoria Dock entrance were reported to have given satisfactory results until the entrance was closed in 1928 for reconstruction of the sills.

With reference to the type of construction adopted for quay walls at the Mudfield, having regard to the loads to be carried and the nature of the materials overlying the ballast, the flexible type of construction was disregarded. The cost of construction of the main quay wall, including the excavation within the authorised section shown in Fig. 12, was about £65 per ft. run.

The Transport Advisory Council Report.

The report of the Transport Advisory Council on the railway companies' application for greater latitude in the fixation of charges for the conveyance of merchandise (H.M. Stationery Office, 1s. 6d. net) contains the following reference to Docks and Harbours.

The Council state that statutory provisions for safeguarding the competitive position of non-railway owned docks have been made by Parliament in various Acts. The railway representatives agree that if the existing control of railway freight charges is to be relaxed it will be necessary to provide other safeguards. The Council approve the terms of an agreement between the railway and dock and harbour representatives, and recommend that, in the event of the present statutory control of railway freight charges being relaxed, the independent dock undertakings should be given a right of making complaint to the Railway and Canal Commission, which should be required to hear and determine the complaint and give such relief as it may think proper.

[Photo, South African Railways and Harbours]

General View of the Docks at the Point, Durban Harbour

Durban Harbour Improvement

Recommendations made by Special Committee

The question of the future development of Durban Harbour has, during the last few months, been receiving careful attention, and after considering recommendations and memoranda submitted, among others, by the Civil Air Board, the Durban Chamber of Commerce, the Durban City Council, and the Natal Chamber of Industries, a Report has been issued by the Committee appointed by the South African Railways and Harbours Administration to advise on the matter. We are indebted to the "Natal Mercury" for the following particulars.

Cargo Accommodation

In the opinion of the Committee, the existing sheds at D, E, F, G and H berths are antiquated, and their replacement by more modern buildings will considerably increase the capacity of the wharves.

"In making this suggestion, the Committee notes that under the original scheme of quay widening and deepening provision was made for the construction of new sheds at the berths in question.

"Owing to the diverse nature of the cargoes handled at Durban it is generally accepted, both from a railway and shipping point of view, that concentration is desirable. Divided organisation does not lend itself to efficient and economic operation. The variety of import cargoes makes it impracticable to introduce a high degree of specialisation in the landing of cargoes."

The Committee considers that the most economical working will be achieved by the concentration of all landing, with the exception of large consignments of single commodities, in one part of the harbour as far as this is practicable.

Export cargoes at Durban, it is pointed out, are unlike imports in that they are made up of comparatively few commodities. More specialised arrangements for export commodities are, therefore, possible, but the considerations which necessitate the concentration of general import cargoes limit the amount of specialisation which is practicable in regard to import cargoes.

Export cargoes may be classified according to their value per ton or their perishability. A high value per ton or a high rate of perishability gives any particular type of cargo a special claim for consideration in the part of the harbour where most shipping is concentrated.

In co-ordinating export and arrangements, the maximum return will, therefore, be secured by the provision of the maximum facilities for cargo of high value per ton or of a perishable nature in that part of the harbour which is used for the landing of general imports.

"The importance of the economies achieved through concentration makes it imperative that the Point should be used as much as possible for general cargo. The diversion of special cargoes from the Point is desirable where it is practicable. The large proportion of the port's general cargo which is carried by passenger-carrying vessels facilitates the concentration of both passenger traffic and general cargo at the Point on a complementary basis."

The Albert Park Area

The Committee is of the opinion that the limited land available in the Albert Park area precludes the possibility of efficient operation in the event of a jetty being constructed into the bay.

"The provision of additional facilities, such as the extension of the Bluff quay, is largely bound up with the question of the development of coal and base minerals in South Africa and not for general cargoes.

"The present facilities and authorised extensions will meet the requirements of the coal and base mineral trade until further considerable development takes place. The Committee is therefore unable at present to make any definite recommendation in respect of quay extensions. In any scheme of future Bluff quay extension, consideration will require to be given to the preservation of the amenities at Fynnland bathing beach."

Future Expansion

The Committee is definitely of the opinion that when the facilities at the Point reach their limit for economic and efficient operation the Administration must concentrate upon the head of the Bay for future expansion.

In arriving at this conclusion the Committee took into full consideration the disabilities attached to divided organisation, but realised that in any scheme of future development other than the Hartley-Barry project (which was definitely rejected by the local community) development of the head of the Bay provides the only practical means for harbour expansion.

The area situated at the head of the Bay, commonly known as "the Bay Lands," is partly owned by the South African Railways Administration and partly by private interests.

A considerable portion of the area is below high-water level and subject to flooding by rivers, and before any practical use could be made of it, considerable reclamation and levelling would be necessary.

It is in this area that the Committee proposes that future quays should be built and, on the Fynnland side of the Bay, an extension to the Bluff quay, should Durban Harbour develop to such an extent as to make existing facilities insufficient to handle import and export cargoes.

Immediately behind the suggested new quays (shown in the accompanying map) ample space would be required to be reserved for the handling of harbour traffic and the provision of goods and marshalling yards, together with an area to provide for the possibility of the railway mechanical workshops being transferred to Congella. This area would include large portions of the reclaimed Bay Lands, Wentworth Lands and portion of the farm Sea View.

"Considerable reclamation work will be necessary in the construction of the proposed additional quays, and it is considered that this work can be undertaken in conjunction with the filling-in and levelling of the existing low-lying lands."

"Immediately behind the area demarcated for railway and harbour purposes is a fairly large tract of land, which could be considered for industrial purposes."

Base for Aircraft

Referring to the recommendations of the Civil Air Board that a site at the head of the Bay should be the most suitable for the provision of a joint land and sea base for aircraft at Durban, the Committee reports that before any decision is taken it will be necessary to have a thorough investigation.

"Although it has been represented to the Committee that this is the only feasible site, the Committee is of the opinion that if at all possible the area should be reserved for industry.

"It is also pointed out that in examining the question of an aerodrome in this area, careful consideration would have to be given to the restrictions which the presence of an aerodrome would impose on structures in the surrounding area.

"It is suggested that the question of the necessity or otherwise of an additional civil aerodrome should be dealt with at the earliest possible moment by the authorities concerned, as the decision arrived at will determine the use which can be made of the surrounding land."

Durban Harbour Improvement—continued

Canalisation of Waterways

Dealing with the canalisation of waterways, the report says that owing to the rapid silting up of the Umbilo River and the consequent risk to the Umbilo River railway and road bridges during floods, it has already been recommended by local officers that the river, as well as the Umhlatuzana River, be canalised.

"Apart from the risk already referred to, very considerable expenditure is being incurred by the railway department in removing silt which is now being deposited in the Maydon Channel."

The Committee considers that this work is urgent. With it is involved the reclamation of the Bay Lands, which will be a lengthy process.

"It has been suggested that provision should be made for the canalisation of the Amanzimnyama River for about a mile towards Isipinge as a first instalment to the opening of the Bay through the river mouth and Indian Ocean. The Committee, however, cannot support this suggestion."

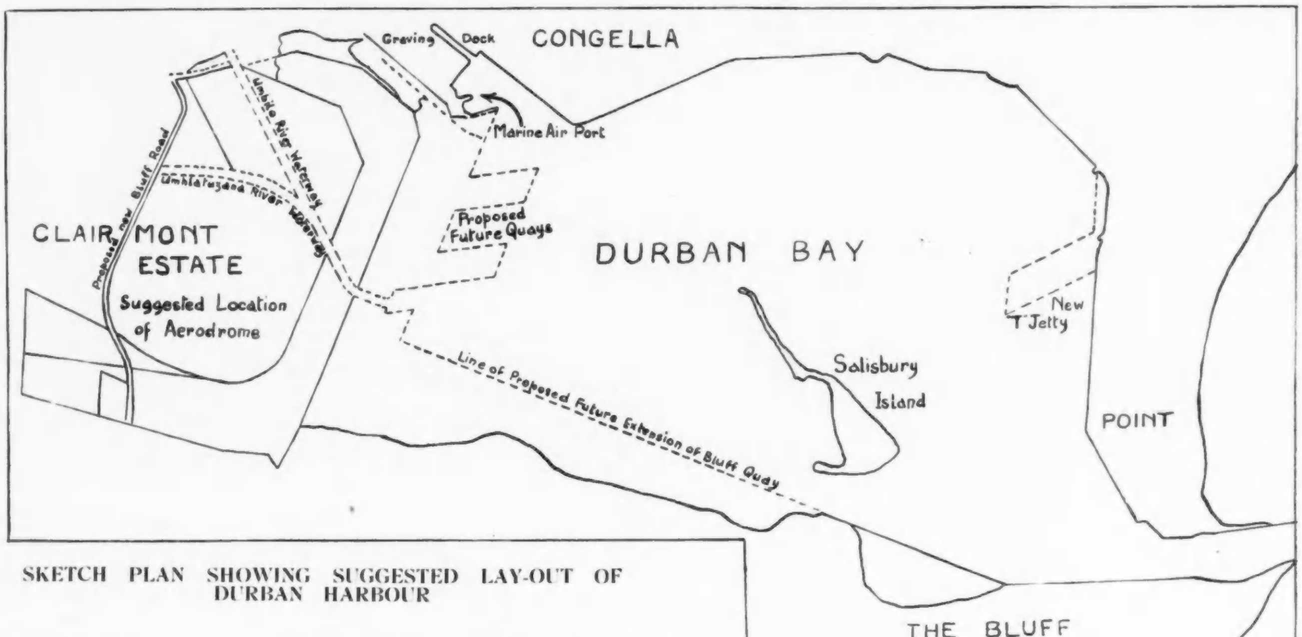
The "T" jetties would economise in space and facilitate the handling of ships in prevailing winds.

For the Bluff a continuous line of wharves was suggested, but it was pointed out that it would be quite practicable to adopt the "T" jetty system there as well.

The width of land required for sheds, roads and railway yards would all have to be reclaimed at the head of the bay. The lay-out allowed for ample space for carriage and wagon shops adjacent to the graving dock, without encroaching on land required for purely harbour requirements and the necessary railway lay-out.

Mr. Brain considered that it would not be advisable to consider the lease of Lots 1, 2 and 3, Block O, Maydon Wharf, to the public.

He recommended that the Administration should consider the adoption of a policy to concentrate such bulk traffic as coal, manganese and other minerals, fertilisers and such commodities at the Bluff, preferably at the farthest end of the bay, and suggested that the manganese and fertiliser traffic now handled by the lessees at Maydon Wharf is a source of trouble to adjoining lessees, whose goods suffer on account of dust.



SKETCH PLAN SHOWING SUGGESTED LAY-OUT OF DURBAN HARBOUR

The question was discussed of making provision within the harbour for possible future shipbuilding activities, but the Committee was not prepared to submit any recommendations in this connection. The future of Salisbury Island was also discussed, but the Committee felt that this was not within its terms of reference.

"The Committee recognises the desirability of encouraging yachting and boating at all ports. A site for this purpose has already been established on the Victoria Embankment and certain provision has been made for the exercise of this sport.

"The Committee feels that further protective and other measures are necessary, and that after agreement has been reached between the bodies concerned steps should be taken at the earliest possible opportunity for the work to be carried out."

Recommendations of the Railways and Harbours Administration

A memorandum submitted by Mr. E. X. Brain, System Manager of Railways in Natal, on behalf of the Railways and Harbours Administration, stated:

"After careful consideration, in collaboration with the senior officers concerned, I am not satisfied that it can definitely be said that the Point will be fully developed on completion of the deep-water berthage, now under construction, and also the 'T' jetty. It would be wise to defer any definite settlement on this point until the Administration had had experience of the operation of traffic at the Point when the works have been completed and brought into use and when any necessary alterations or additions to Congella marshalling yard have been made to relieve the Point area of any unnecessary shunting."

Mr. Brain felt that with the added facilities which the additional berthage could provide, there would be ample time to arrive at a decision as a result of experience before the necessity arose of constructing additional berthage, either at the Point or at the head of the bay.

He submitted plans to illustrate what could be done to extend wharfage at the head of the bay and at the Bluff and a tentative scheme for the construction of sheds, sidings and possibly goods sheds.

At the head of the bay two "T" jetties were suggested and the allocation of land for harbour requirements and a future marshalling yard.

Views of the Durban Chamber of Commerce

The Durban Chamber of Commerce in a Memorandum to the Committee submitted that Durban's economic activities were based on distribution, manufacturing and tourism, and that harbour development should take cognisance of each of these factors.

The maximum of expedition with the minimum of cost in the transport and handling of goods consigned to or from the port were the primary objects in the development of the harbour. Full achievement of this object called for the recognition of all the factors affecting the general movement of goods into or out of the harbour before attention could be paid to the requirements of any individual exporter or importer; civic amenities; tourism; aviation and defence.

On grounds other than economic, it might be found desirable to sacrifice a certain amount of harbour efficiency in favour of increased attention to one or more of these five factors, stated the Chamber. Such a sacrifice would obviously be in the interests of the port, if it were necessary for reasons of defence.

The Chamber was not prepared to state that a sacrifice on account of any of the other factors would be incompatible with a long view of the interests of the port, and believed that adequate provision could be made for all reasonable individual requirements, the preservation of civic amenities, the convenience of tourists, and the requirements of aviation without any alteration of plans based on the view that the economic movement of cargo was the paramount function of the harbour.

The Chamber submitted that the variety of import cargoes received in Durban made it impracticable to introduce a high degree of specialisation in the landing of cargoes. The only other means of achieving economy was through the concentration of all landing, with the exception of large consignments

Durban Harbour Improvement—continued

[Photo, South African Railways and Harbours]

Durban Bay, showing Coaling Station in left foreground, the Docks at the Point in right foreground and the Oil Station in centre background

of single commodities, in one part of the harbour so far as this was practicable.

" Export cargoes are unlike imports in that they are made up of comparatively few commodities," states the memorandum. " More specialised arrangements for export commodities are therefore possible, but the considerations which necessitate the concentration of general import cargoes limit the amount of specialisation practicable in regard to export cargoes.

" The export cargoes may be classified according to their value per ton or their perishability. A high value per ton or a high rate of perishability gives any particular type of cargo a special claim for consideration in the part of the harbour where most shipping is concentrated.

" In co-ordinating export and import arrangements, the maximum return will, therefore, be secured by the provision of maximum facilities for cargoes of high value per ton or of a perishable nature in that part of the harbour which is used for the landing of general imports."

The question of the extent of the future demand at economic rentals for sites for factories which require a direct water frontage as an indispensable condition of their business was one which demanded consideration.

" In spite of the large area of the harbour, the unknown needs of the future preclude recognition of any demand for such a site at a rental which is not economic, but consideration should be given to the requirements of any industrial undertakings which find that the advantages of a harbour site override the comparatively heavy overhead expense of an economic rental on reclaimed land.

"At any particular time only the largest industrial undertakings will be able to use a private wharf to such an extent as to render the interest, depreciation and maintenance charges per ton of goods landed and shipped comparable with those at a public wharf in a busy harbour. The demand for harbour sites will, therefore, have no necessary relationship to the rapidity of Durban's industrial progress."

The Chamber considered that an extension of the zone rate system would bring a considerable amount of municipal and privately-owned land, the use of which could not be considered by industrialists under present circumstances well within the economic region for industrial sites. This would have the additional advantage that workers engaged in industries situated in such sites could be housed near their work.

The municipal rates on land outside the harbour area would also be substantially lower than those on private leasehold sites within the harbour area, the rental of which would reflect the cost of reclamation.

" The difficulty which will call for increasing consideration as the business of Durban Harbour grows, will not be one of an adequate water surface but of the restricted acreage of land in many parts of the harbour area. The narrowness of the Point, the close proximity of the harbour to the more highly rated parts of the city, the large areas required for marshalling railway trucks, the possible requirements of aviation, and the rising contour of the Bluff all tend to limit the amount of land available in the harbour area to an extent which only leaves a small margin for any additional requirements other than those of the most general nature.

" The provision of all the necessary facilities for passengers and their baggage presents few difficulties when the berthing of passenger-carrying vessels is concentrated in one part of the harbour. Transport and customs considerations are particularly important in this connection. It is also desirable that the location of such berthage should take into account the need for easy access to the centre of the city.

"The point of arrival of passengers coming to Durban by sea-plane should also be in as convenient a position as possible from the point of view of access to the city. It should also take into account the need for providing the quickest possible means of changing from sea-planes to land-planes."

Berthage, Cargo and Passenger Accommodation

The Chamber also felt that the completion of the deep-water berthage between " I " shed and the Esplanade and of the new pier would meet the port's existing berthage requirements.

The Chamber was of the opinion that the existing shed facilities at the Point are not fully utilised. Their effective capacity would be greatly increased if imports and exports were stored in separate places. This arrangement depended on the provision of modern overhead transport gear. Even with the more efficient working which would be possible with improved gear, the shed accommodation would still be seriously inadequate. A satisfactory position was dependent on a considerable enlargement of existing accommodation.

The ideal arrangement would be one in which there were double-storey sheds, of which the ground floors were reserved

Durban Harbour Improvement—*continued*

for imports and the upper floors for exports. There was no doubt that the existing sheds were very much out of date. Larger sheds with modernised mechanical equipment would increase the dispatch with which cargoes could be handled and would obviate existing delays, which held up railway trucks for unnecessarily long periods.

Consideration should be given to the question whether sufficient cargoes could be diverted to new wharves beyond Maydon Wharf for special cargoes. The large portion of the port's general cargo which was carried by passenger-carrying vessels facilitated the concentration of both passenger traffic and general cargo at the Point on a complementary basis.

The Point's proximity to the centre of the city made it a convenient centre for passenger traffic, but the harbour was seriously lacking in facilities for passengers. The provision of these facilities was desirable also in the interests of people meeting passengers or seeing them off.

"The obsolete nature of the facilities for the landing and shipping of passengers and their baggage and the absence of waiting rooms are not in keeping with the fact that more than 60,000 passengers land or embark in the course of a year."

The Chamber pointed out that the Administration had laid down that the landing and shipping rights enjoyed by Maydon Wharf leaseholders would not be allowed in the leases of any other area which might be reclaimed. The number of undertakings which could take full advantage of such rights would always be limited because as the harbour grew the potential value of landing and shipping rights would increase.

The difficulty was increased by the fact that whereas the Maydon Wharf scheme was instituted to compete in a particular kind of traffic with Lourenco Marques. new reclamation schemes would be due to the normal growth of Durban.

The Chamber was of the opinion that due provision would have to be made for future railway and aviation needs at the head of the bay before other claims on this area could be considered.

The desirability of the Administration reducing the pressure on the harbour area by making a substantial increase in the area of the zone rate with a view to facilitating industrial development at Clairwood and in other areas was emphasised.

The Chamber considered it desirable to reserve the oil wharf at Island View for its present use.

"It is unsatisfactory that a tourist ship, such as the "Franconia," should have to move over from the Point to Island View to take in oil. The absence of oil facilities at the Point is not consistent with Durban's importance as a port and the institution of provision for oil facilities at the Point by pipe line or by the provision of one or more barges is essential."

Further, the Chamber stated: "The volume of manganese which has recently been exported could not have been handled if certain facilities for exporting coal had not been used for manganese, and in the interests of coal exporters as well as base metal exporters, it is desirable that immediate provision should be made for base metal exports from the Bluff in the form of an additional wharf between the coaling berthage and the oil sites."

The Chamber supported the canalisation of rivers flowing into the bay.

Views of the South African Conference Lines

The Durban representatives of the South African Conference Lines through their chairman, Mr. H. W. D. Frudd, submitted a memorandum in which they pointed out that, assuming 30-ft. as the least draft for modern vessels, Durban has accommodation for four vessels of this draft, compared with nine at Capetown and eight at Port Elizabeth, indicating that the two new berths and proposed jetty were urgently required.

"Taking the existing length theoretically, the Point should accommodate 12 vessels of an average length of 500-ft. each, but as almost half of the total quayage of 6,266-ft. has a depth of only 23-ft., it indicates a serious position at the Union's premier commercial port."

The memorandum pointed out that provision was being made for nine additional deep-water berths.

"The sheds at the Point are definitely incapable of accommodating imports to their capacity nor, generally speaking, is provision made for export cargo being received into sheds any appreciable time before the loading of ships."

The memorandum also supported the idea of double-storey sheds, the upper floors being for exports and the ground floors for imports.

"The enlargement of existing sheds or the installation of modern stacking facilities in the sheds would tend to the quicker dispatch of ships. If and when it may be possible to allocate sheds to regular liners, the matter of shed accommodation would be greatly alleviated."

It was submitted that the present number of cranes is wholly insufficient. The provision of additional cranes to the extent of at least six for each berth with 10 to 15-ton cranes interspersed at intervals would obviate the present position where ships are required to wait for a floating crane, thus causing unnecessary delays.

Regarding the berthing and unberthing of ships, particularly in summer when there are many hours of daylight, the memorandum continues: "The present rule of the port is that the marine staff commence work at 6 a.m., and by the time vessels are taken out to sea and other brought in, a considerable amount of valuable working time is lost, including time occupied by the medical and immigration authorities."

More facilities for loading ore were also recommended; should the mineral export not increase, these facilities would add to the existing facilities for the expeditious loading of coal.

The Conference Lines also required facilities for taking in oil without ships having to go to Island View by the provision of a pipe line or barges.

Further, it was imperative that up-to-date facilities should be provided for the landing and shipping of passengers.

"The concentration of passenger-carrying vessels at the new pier would generally facilitate the work of the port, and consideration might be given to the provision of passenger trains to and from the area."

[Photo, South African Railways and Harbours]

Aerial View of entrance to Durban Harbour

The memorandum also mentions that the pre-cooling facilities at "B" shed are inadequate.

It was urged that developments at the bay head should be used for cargo vessels and that all passenger ships should be berthed at the Point. Another suggestion was that the Island Channel should be deepened to make for a shorter exit from the harbour.

Suggestions of the Natal Chamber of Industries

The Natal Chamber of Industries submitted a memorandum on the limited amount of land, municipal, Government or privately-owned, available in Durban for industrial purposes.

"Since the scheme for the development at the head of the bay was first mooted by the Chamber the question of increased wharfage accommodation has become of paramount importance. Owing to acute congestion at the Point and in view of the urgent necessity of alleviating the position in the near future, the Chamber signified its approval of the proposal of a 'T' wharf in the area, fully realising that development at the head of the bay could not stand in the way of providing for the present urgent requirements for more wharfage space.

"It is felt that the position of extra wharves and the development generally of Durban Harbour to meet the increased demand of shipping and trade is better left to other members of the Committee who are more acquainted with the position than we are.

"The Chamber is, however, strongly of the opinion that when the extensions to the wharfage at the Point are completed no further extensions in this area should be considered and, taking the long-range view, are unanimously of the opinion that development at the head of the bay should have the earnest and careful consideration of the Administration."

The Chamber considers that the natural development of Durban industrially is at the head of the bay, because this area would appear to be ideally situated for factory sites and because of its proximity to the Maydon Wharf industrial area.

When deciding on a site for certain factories, a major point was convenience of a wharf with available road facilities. The canalisation of the rivers flowing into the bay would serve a double purpose in that transport by water would be available to factories adjacent to the canals and the "Umbilo Smell" would be eliminated.

Durban Harbour Improvement—continued

The reclaimed land would provide space for factory development with or without wharfage accommodation and sites for Native housing. The Bluff and the land owned by the Municipality at Clairwood would then be suitable areas for the housing of European employees.

Observations by the Mayor of Durban

Mr. Fleming Johnston, Mayor of Durban, as the member representing the Durban City Council on the Durban Harbour Development Committee, submitted observations and suggestions for the consideration of the Committee.

The trend of Durban's harbour development, he said, had emphasised the fact that the establishment of the Congella industrial area, with shipping facilities in proximity, was more than justified. The congestion experienced at the Point from time to time might have created chaotic conditions had not Congella been established.

The more recent diversion of railway traffic from the track that seriously inconvenienced traffic in the heart of Durban to the mile across the bay was another factor in illustrating that Durban's industrial progress centred round the head of the bay. The Railway Administration had previously transferred its marshalling yard to Congella and thus concentrated the receipt and despatch of goods traffic from the recognised industrial centre.

" Industry sensed the advantages of better shipping facilities offered by closer access to the water front, with the result that to-day almost the entire land available in the Congella industrial area is taken up. Congella's development has been so marked that it has had the effect of transferring the activities of large industrial concerns from other parts of the city to be concentrated in the accepted industrial centre, thus making available sites for the expansion of business activities in other spheres."

Though localised at Congella, Durban's industrial expansion had not been entirely confined to the harbour area, for important industries had been set up on the Bluff side and to the south as far as Merebank. The City Council had realised the trend of affairs and had set up a Native village near Clairwood to provide Native labour, and had also purchased land at Clairwood for industrial development.

" As recently as last year the Council adopted the principle that the head of the bay was to be regarded as the natural location of industrial development. It has also been foreseen by the Council that more adequate facilities should be provided for the easier access to the Bluff lands.

"At the present time Bluff development is retarded by reason of the fact that access is only provided by means of the much used South Coast Road and a long and unsuitably devious route. A shorter and more direct route is sought and considered to be highly desirable, both from an industrial and residential point of view. A sum of £2,000 is provided in the current estimates for the preliminary survey for a road across the head of the bay."

The City Council regarded any development of the Durban Harbour as being almost entirely confined to the head of the bay and to the south and south-east towards the Bluff.

In all other essentials the Council had been able to offer facilities such as good water, cheap power and sanitation conditions that compared favourably with any city in the country, but the rapid expansion of industrial development had rendered it necessary to look well into the future in formulating an extension programme.

From the Council's point of view it was in the direction of catering for the needs of industry that its interest chiefly lay. The actual technical phases of any scheme were more the concern of the Government, and the views put forward must be regarded in that light. The Fynnlands and Congella Beach must not, however, be overlooked.

The Point should be developed primarily for handling passenger-carrying vessels, and no additional facilities should be provided for vessels whose only function was carrying cargo.

A boat and yacht harbour should be provided for, with lock-up boat-houses. A boat harbour formed by a mole of rock starting from the vicinity of the Royal Durban Yacht Club House and of such a length as to overlap the Gardiner Street jetty, would afford protection from westerly busters; the level of the mole to be one foot below high water at spring tides to prevent rodent infestation and to be sand banked on its south-westerly face to save complete wreckage of boats or yachts which might be driven against it.

A ferry boat channel across the bay would be a desirable amenity for cheap transport of workers living on the Bluff.

The head of the bay provided the one direction in which development was called for. This should be regarded as the principal area for handling cargo ships and should be provided with storage facilities which were not available at Maydon Wharf.

In order to prevent a recurrence of the situation which arose in connection with the disposal of land by the Railway Administration to the City Council in the Maydon Wharf and Congella industrial areas, it was considered that the ownership of the land lying between the dock area and the South Coast road and the proposed road across the head of the bay should be vested in the City Council, which should be free to regard it as land for industrial development and to be disposed of as such.

It was also considered that this area should be reclaimed by the Administration as part of the general scheme of dredging and other essential works that would be necessary for the proper development of the area and thereafter transferred to the City Council.

Canalisation of the Umbilo, Umhlatuzana and Amanzimnyama Rivers would be an essential feature of the reclamation of this area, and the layout of these canals would provide water-side industrial sites. Canalisation of the Amanzimnyama River for about a mile towards Isipingo should be undertaken as a first instalment to opening right through to the river mouth and ocean.

" With all our natural and other resources at hand—coal, iron, timber, electricity, water, is there any reason why the Union should not build its own and other ships as Japan and other countries do? Provision should be made to encourage and develop an industry of such potential national importance," said the Mayor.

The Bluff, from Fynnlands Station westwards, should be developed as a pleasure resort. The wharfage from the oil sites to a point to be reclaimed towards Maydon Wharf should be extended on piles to allow free passage of tide-water to the beach. A similar viaduct wharf should be planned for a beach at Congella.

Publications

The Strength of Long Reinforced Concrete Columns. (No. 24, published by H.M. Stationery Office, 9d. net).

The Department of Scientific and Industrial Research has issued a Building Research Technical Paper dealing with the strength of long reinforced concrete columns in short-period tests to destruction. The paper is the seventh in a series of studies in reinforced concrete. It is pointed out that it is impossible to avoid some eccentricity of loading in a reinforced concrete column, and the column bends as a result. When the column is short, the lateral deflection is usually unimportant. But in a long column, particularly at high loads, an appreciable increase in the eccentricity of the load from the column axis is introduced; the bending stresses are thereby magnified; and the ultimate strength of the column is diminished.

The present paper describes an investigation undertaken to determine the strength of long columns in short-period loading tests to destruction for cases when the initial eccentricity of loading is small, that is, of the order that may be regarded as " accidental " in practice. The work was carried out in co-operation with the Reinforced Concrete Association.

It is impossible, even for well-defined initial conditions of loading, to carry out a rigorous, mathematical analysis of the stress distribution, which, in view of the effects of the creep of the concrete, must be in some way a function of the time under load. The experiments described have shown, however, that a simple approximate analysis can be used to estimate the strength of long columns for the conditions specified.

The International Power Review, the first issue of which for May has recently appeared, is a Journal designed to give each month a condensed report of the most outstanding developments in each country where engineering is one of the most important industries, with sufficient details to keep engineers informed of modern progress in reseach, manufacturing technique and industrial applications. The price is one shilling monthly (46, Southampton Row, W.C.1).

The Board of Trade have issued at a price of 4d. net (H.M. Stationery Office), their Provisional Scheme for the Re-insurance of the Marine Insurance Market in so far as concerns King's Enemy Risks on Cargoes destined for discharge in or shipped from the United Kingdom.

Bombay Port Trust Preliminary Report.

At a meeting of the Trustees of the Port of Bombay held early last month, a preliminary report on the working result of the year ended 31st March, 1939, was submitted. The actual receipts on General Account amounted to Rs. 233.48 lakhs, or an increase of Rs. 2.67 lakhs over the Revised Estimates framed in January last. The increase is mainly due to greater imports of petrol and fuel oil and a greater demand for Cotton Depôt godowns and leasehold land during the last quarter of the year. Taking into account probable further savings in expenditure, the net result of the year's working should be a surplus of about Rs. 4½ lakhs.

*Port Working**

By K. G. FENELON, M.A., Ph.D., M. Inst. T.

Ports are a link connecting sea and land transport and their function is to provide facilities for the loading and unloading of cargoes, or the embarkation or disembarkation of passengers. This implies that they should provide shelter for ships in order that the operations may be easily carried out. They must be able to provide accommodation for any ship that is likely to use them, though all ports need not cater for the very largest ships.

In general, ports are tranship and not terminal points. Their efficiency, therefore, is to be judged by the two tests of (a) low cost in handling traffics in the process of transhipment, and (b) the rapidity with which the operations can be carried out. The necessity of low cost is obvious; sea transport costs are very low, but if port dues and rates are high, this will appreciably increase the all-in cost of transport. The latter requirement is also essential, because a ship has a high initial cost, and it can only be made to pay if given a quick turn-round at ports. A ship moving on the seas is generally earning money; a ship in dock is merely costing money.

In the layout of a port on the land side, it is essential that care should be taken to avoid congestion. Thus, railway tracks and sidings should be ample, and adequate provision made not only for the arrival of trains, but also for the removal of empties.

Another point that requires attention is the co-ordination of ocean transport with the inland waterways. There should be ample facilities for loading or unloading overside to or from canal barges. Where this can be done, costs are reduced.

At many general ports, an increasing volume of traffic is now handled by road transport. Congestion easily occurs, especially at older ports, where space is limited. Good approaches are, therefore, essential if vehicles are not to be kept waiting.

Handling appliances merit special attention, since they are so important in facilitating the movement of ships into and out of the port. The shipowner gains if his ships can be "turned round" quickly, and so do the port authorities, since more ships can be dealt with in a given time and with a given dock space. Mechanical and labour-saving devices are essential, though there are yet many ports in this country where out-of-date appliances are in use. Cranes must be amply provided and must be of a type suitable for the traffic handled at the port. Steam, electricity or hydraulic power is used at various ports to drive the cranes, hoists, capstans, etc., and each has its advocates, though there is actually little to choose between them. On the whole, probably electric power is now the most favoured, because each appliance can be fitted with its own motor, and it is very convenient in use. Appliances can also be increased in number as required without involving expensive capital equipment.

Bulk cargoes, such as grain, ores, oil, coal, are generally handled by appliances capable of maintaining a steady and continuous flow. Thus grain is raised from the ship's hold either by pneumatic elevator, or bucket elevator. It is then carried by conveyor belts to silos or elevators where it can be sorted, cleaned and put into bags. For loading ships, grain is run out of the elevators on conveyor bands which lead to spouts discharging into the ship's hold.

The pneumatic system of unloading is rather more costly in power, but is more convenient as no manual feeding is required, as is necessary with bucket elevators. Also, the nozzle of the suction pipe can easily be taken into corners and distant parts of the hold. With bucket elevators, there is always a difficulty in raising the last portions of the grain.

General Cargoes—that is, goods packed and handled in packages or containers of various types, e.g., bags, cases, crates, bales, barrels, cans, drums, etc.

The distinction between bulk and general cargoes is important, because they require different treatment in handling, and the equipment necessary for loading and unloading is also different.

General cargo is of great diversity in size, weight, shape, and packing. It is extremely difficult to handle it by systematic means, such as is possible with coal, grain, ores or oil.

Of course, where a large consignment is fairly uniform, e.g., sacks of flour, chests of tea, carcases of mutton, it would be possible to utilise an elevator and conveyor. Normally, however, the cargo in a ship's hold is very far from uniform, and it is generally stacked so as to obtain maximum capacity from the hold rather than for convenience in unloading.

Unloading equipment must, therefore, be capable of dealing with all kinds of goods from locomotives or girders to small crates of fruit or bundles of plywood. Cranes are the main form of equipment utilised, as they can be adapted to all kinds of conditions.

On landing, cargo, unless it is in bulk and ready for immediate transfer to lighter or wagon, is landed on the quay or wharf and then taken into a transit shed for sorting and dispatch. Transit sheds should not be used for storage purposes, since otherwise the berth will not be clear for the next ship that arrives. It is customary to give all consignees a free period, generally up to 72 hours in which to claim their goods.

* Paper (abridged) read before the Hull Traffic Association on 4th April, 1939.

Soil Mechanics

The forty-fifth James Forrest Lecture was delivered at the Institution of Civil Engineers on Tuesday, 2nd May, by Karl von Terzaghi, Dr.-Ing., M.Inst.C.E., the Lecturer taking as his subject "Soil Mechanics—A New Chapter in Engineering Science." Dr. von Terzaghi commenced his Lecture by comparing present-day knowledge in soil mechanics with that of former times, and he stressed the much greater reliability of up-to-date methods of allowing for the effects of soil-movements and pressures. Dealing first with the pressure of earth on lateral supports, he reviewed Coulomb's and Rankine's theories, and showed that the assumptions made therein were not justifiable. The various facts concerning the pressure on lateral supports were then considered, and Dr. von Terzaghi showed that the combination of those facts excluded the application of earth-pressure theories of any type to the computation of the pressure exerted by soft clay; the pressure of clay on lateral supports could only be learned from experience gained from actual measurements, very few of which had been made. In consequence, the knowledge of the subject was quite inadequate for rational designing. The Lecturer continued by stating that the pressure-distribution behind a vertical wall supporting a cut in sand was approximately parabolic, the centre of pressure being located in the vicinity of one-half of the depth of the cut; that conclusion had been proved experimentally.

Dr. von Terzaghi then considered the stability of slopes, and referred to the use of what was known as the Swedish method of determining the degree of stability of a slope; that method was based on the empirical fact that the profile of the surface of sliding always approached the shape of a circular arc. If a submerged body of soil having little or no cohesion were in a loose state, an insignificant external or internal disturbance would be likely to transfer the soil temporarily into a liquid state, causing it to flow on a horizontal surface; that phenomenon was known as a "flow-slide," and depended upon the material being able to be reduced to a denser state. In a dense sand, however, every deformation produced a tendency to expand, thus excluding the possibility of a flow-slide. At some intermediate porosity the material neither expanded nor contracted. The Lecturer then referred to a proposed method for determining that "critical porosity," to decide whether or not the danger of a flow-failure existed.

Dr. von Terzaghi then referred to the failure of dams by piping; he concluded that piping could be eliminated by the provision of an "inverted filter" between the body of the dam and the foundation, and he described a filter that he had designed for a rockfill dam in Algiers.

In connection with the consolidation of clays, and its practical consequences, he gave as examples various works in which pumping had caused serious settlement, and he pointed out that such settlement could now be computed reasonably accurately.

The Lecturer then dealt with the settlement of footings and of raft foundations, and pointed out that the assumption of "allowable bearing pressure" was unjustified, since settlement was liable to occur no matter what bearing pressure was assumed, and was not necessarily uniform for a uniform pressure-distribution. He then showed that a flexible supporting raft was often more suitable than a rigid raft, as unequal settlement would not cause it to crack. Settlement actually depended on the character of the soil-profile to a depth of at least 1½ times the width of the building, on the size and spacing of the footings, on the depth of the foundation, and on the location of the footings or loaded sections of the raft with reference to the outer boundaries of the area covered by the structure. If the subsoil contained beds of clay the settlement was also a function of time. Referring to the settlement of piled foundations, he stated that pile-driving formulas were dependable only in a few exceptional cases, and he gave examples of structures in which serious settlement had occurred in spite of satisfactory pile-loading tests.

The fundamental requirement for an adequate forecast of settlement was an intimate knowledge of the compressibility of all clay strata contained in the subsoil down to a depth equal to at least 1½ times the width of the area covered by the structure, and Dr. von Terzaghi described sampling apparatus for that purpose. Finally, he expressed the opinion that the responsibility for failures would soon be placed on designers who refused to take notice of the existence of soil mechanics.